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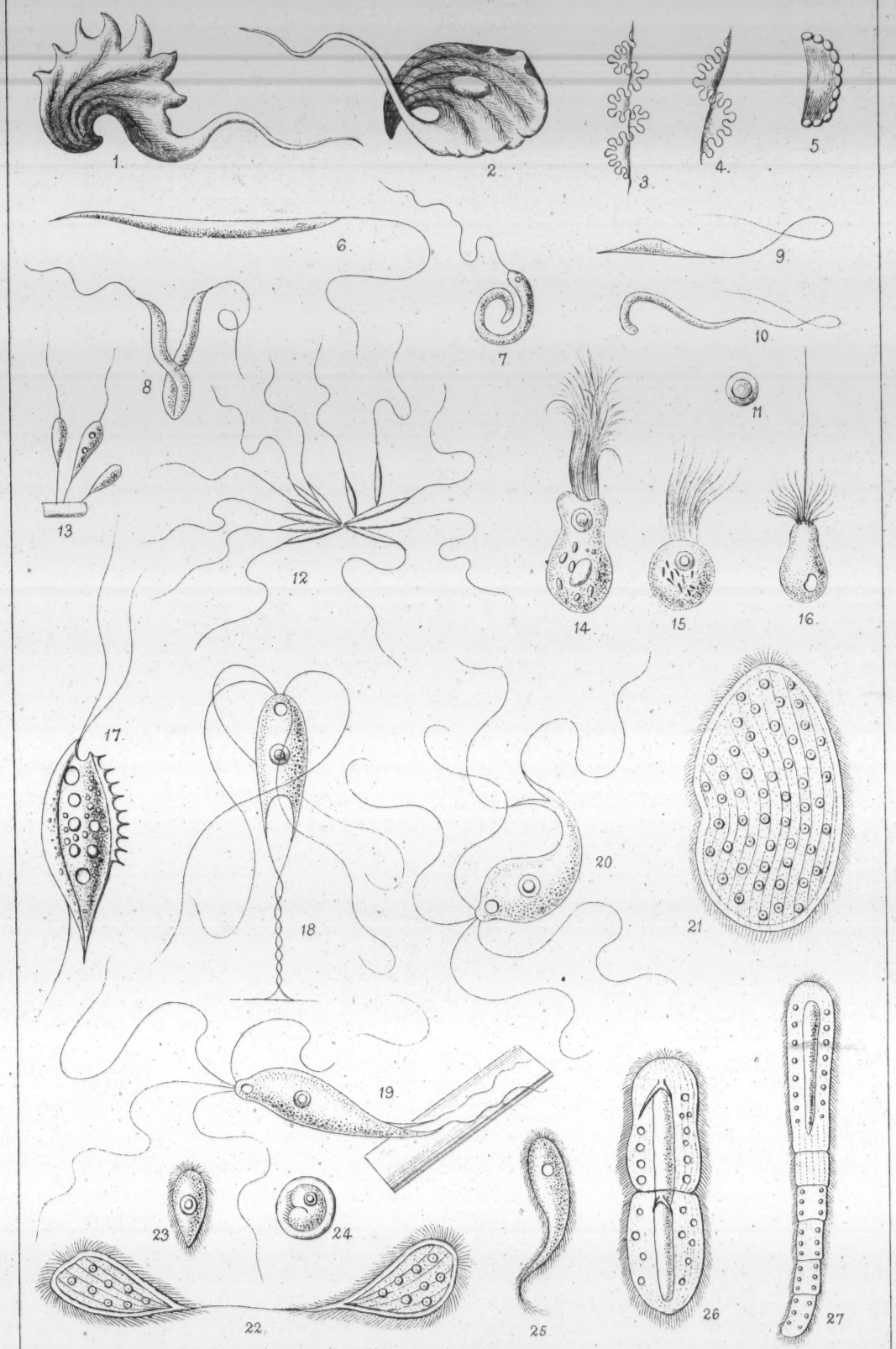

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AN irresistible halo of fascination is ever associated with the structural details and life-phenomena of those beings to whom other and mostly higher representatives of the animal kingdom extend shelter and protection, and afford, if not direct sustenance, free lodging and a *modus vivendi*.

To the practical biologist such animal types are of peculiar interest, since such an acquired and artificial phase of existence is most often correlated with structural modifications of the most abnormal order, and which in themselves testify volumes as to the capacity and tendency of organic forms to adapt themselves to surrounding conditions, and, losing all trace of their pre-existing distinctive features, to develope into something different, or into what, for convenience sake in zoologic terminology, is denominated a new or independent 'species.' Such forms, again, recommend themselves to the evolutionist as the latest products of Nature's crucible; since, many of them being the satellites of the highest and most recently developed organic types, they must, *pari passu*, have acquired their own typical characteristics still more recently.

So far, the examples of parasitic existence with which the student of zoology is most intimately conversant, are found within the precincts of the Arthropodous and Vermiform subdivisions of the invertebrate sub-kingdom. Among the groups or types, which may be suitably cited in this connection, may be mentioned more especially the innumerable Entozoic and Ectozoic Worms, comprehended within the several orders of the Trematoda, Cestoidea, Nematoda and Acanthocephala; also the retrograde and singular Crustacean forms, represented by the ectoparasitic Lernæidæ and other Epizoa, and including also, as near relatives of the Barnacles and Acorn-shells, or Cirripedia,

those most oddly metamorphosed types, *Peltogaster* and *Sacculina*. The hosts of species that are referable to the parasitic category from among the ranks of the insect world are too innumerable, and, in many instances, too familiar, to need quotation; even the comparatively small class of the Arachnida furnishes its quota towards the augmentation of the present list, as instanced by such types as the *Pentastomum*, *Demodex*, and the abundant representatives of the Tick family, or Ixodidæ.

The object of the writer of this article is not, however, to descant at length upon the attractions presented by the members of the above-named highly-organized Metazoic groups, but to direct attention to an assemblage of organisms that exhibit parallel ecto- and endo-parasitic life-habits, and in many instances, precisely analogous, adaptive modifications with reference to their respective modes of existence, but which hitherto, on account chiefly of their exceedingly minute size, have received but scant notice. All the representatives of the group in view are, in point of fact, microscopic organisms, belonging to that subdivision of the Protozoic sub-kingdom, known as the Infusoria, for whose correct comprehension, and for a knowledge indeed of the very fact of their existence, we are dependent upon the assistance and revelations of the compound microscope.

Before entering upon a survey of the very considerable series of Infusorial forms that are associated with some one or other of the many varied phases of parasitic growth, it is desirable, perhaps, to briefly indicate the broader lines of demarcation by which this assemblage of organisms is to be distinguished from all collateral zoological groups, and also the more important secondary subdivisions, or orders, into which the Infusoria as a whole may be most naturally and conveniently subdivided. The Infusoria, as now most generally conceded, are to be regarded as unicellular animals, possessing individually the morphological value only of a simple histologic cell, having, in the majority of instances, a distinct cell-wall and enclosed nucleus, and multiplying abundantly by a simple process of binary subdivision. As here recognized, all infusorial forms possess, in addition to the foregoing essential characteristics, locomotive appendages which take the form of cilia, flagella, or prehensile, and mostly suctorial, tentacles. With but rare exceptions, the Infusoria manifest the capacity of ingesting solid food-substances, either by a distinct mouth, by many mouths, or through the general surface of the body; even yet more invariably, they possess one or more definitely located, rhythmically expanding and contracting spaces, serving as excretory organs, and to which the title of contractile vesicles is most usually applied. Various other phenomena pertaining

to the structural and reproductive phenomena of the Infusorial organism might be cited, but those already given suffice for existing exigencies.

Proceeding to an enumeration of those representatives of the Infusorial series which fall within the legitimate scope of this article, the term Parasite, as here employed, at once confronts us and demands a brief exposition of its significance. But a few years since, this term comprehended every organism that was, under any form, found associated with, or attached to, some other specific type. Credit is due, however, to the Belgian biologists, Paul and Edouard Van Beneden, for having pointed out that there is a very large assemblage of animals usually comprehended under this collective term of Parasites, that in no way live at the expense of the animal organisms, generally of higher rank, with which they are found associated, but are beholden to them only for free lodgings, providing their own larder, or, at the most, contenting themselves with the crumbs that fall from their comrades' table. For animals which maintain towards their selected host so purely amicable a relationship the title of 'Parasite,' implying an organism that lives upon or at the expense of another, has no true significance, and, recognizing the desirability of the introduction of a title that should more precisely indicate this peculiar relationship, the authors quoted have bestowed upon them the distinctive one of 'Commensals.' Familiar examples of 'Commensalism,' as distinct from 'Parasitism' in its true and restricted sense, are afforded by such forms as the well-known, so-called Parasitic Sea-anemones, *Sagartia parasitica* and *Adamsia palliata*, found attached to the shells of Gasteropodous Mollusca inhabited by Hermit crabs; and with which last-named Arthropods they are reported to cultivate so intimate an acquaintance as to secure their own transfer at the hands of their host to the next convenient abode which its constantly increasing bulk obliges it to occupy.

The extensive tribe of the Cirripedia, including the Barnacles and Acorn-shells, yield also an extensive series of Commensals; certain of them, such as the genera *Tubicinella* and *Coronula*, are respectively only found attached to, or deeply immersed within, the epidermis of various Cetacea; while another form, *Pyrgoma*, takes up its abode within the midst of the polyparies of reef-building corals, and is met with under no other conditions. These, and innumerable other species ordinarily denominated parasitic types, in no way prey upon the vital or nutrient juices of their elected host, after the manner of true Parasites, but, at the outside, simply take 'pot-luck' and a small share of the good things consumed by the latter. Quite as frequently indeed they cater for themselves independently,

accepting only free lodging, and it may be the means of transit, at the hands of their co-sociates.

It is proposed in the present instance to direct attention only to the consideration of the innumerable forms of Infusoria which are referable to the category of 'Parasites' in the strictest and simplest sense, postponing, possibly, to a future occasion an account of those that lead a commensal life. It will be found most convenient to examine these parasitic types in association successively with the three primary classes of the Flagellata, Ciliata, and Tentaculifera, commencing with the first-named or lowest in the organic scale.

The Flagellata, but recently recognized as forming a clearly delimited and natural group of the Infusoria, are found to exhibit several very important modifications with relation more especially to their oral or inceptive systems and the character of their locomotive appendages, these furnishing indeed the basis upon which the present writer has established the various, and mostly newly introduced, orders of the class, embodied in a treatise devoted to an account of all known Infusorial organisms, now in course of publication.* The lowermost term in this series, as represented by the order of the Trypanosomata, is remarkable for containing two species only, *Trypanosoma sanguinis* and *T. Eberthi*, both notable for their essentially parasitic habits. The first of these, as represented in Pl. VII. Figs. 1 and 2, occurs abundantly in the blood of Frogs and other Amphibia; whilst the second, Pl. VII. Fig. 3–5, has been obtained as a parasite of the intestinal viscera of ducks and geese. High interest is attached to both of these, inasmuch as they represent the Flagelliferous series of the Infusoria in its most rudimentary condition. In neither instance is a flagellum distinctly developed, but in *T. sanguinis* one extremity is produced in a tag-like manner, and by the movements of this, combined with the undulations of the thinner lateral margin of its compressed body, it makes rapid progress through the fluid medium it inhabits. In *T. Eberthi* there is no tag-like anterior prolongation, the lateral margin being, however, developed as a still more conspicuous undulating, frill-like border. It is a remarkable fact that the contour of this last-named type corresponds to a very considerable extent with that exhibited by the spermatozoa of certain Amphibia, and more especially with those of *Bombinator igneus*, as originally figured by Leuckart and Siebold. This circumstance not unnaturally leaves grounds for some slight shadow of doubt as to whether this reputed species can be justly regarded as an independent form, or whether it does not represent the spermatic elements

* *A Manual of the Infusoria*, by W. Saville Kent, F.L.S., F.R.M.S. Part I. October, 1880. David Bogue, 3 St. Martin's Place.

of Amphibia which have been devoured by the water bird, and temporarily retained their vitality within its viscera. Premising, however, that the position of *Trypanosoma Eberthi* as a independent organism is established, yet another problem of interest presents itself; for until the entire life-histories of both this and *T. sanguinis* have been investigated, the possibility remains that the type found in the viscera of ducks and geese may represent an advanced phase only of the one inhabiting the blood of the Amphibia, or *vice versa*. A parallel association with two separate hosts is of common occurrence among the representatives of the Cestoidea and other endoparasitic worms.

From among the group of the typical Infusoria-Flagellata, numerous illustrations of true parasitic existence may be cited. The genus *Herpomonas*, as recently instituted by the present writer, embodies two specific forms, *H. muscæ-domesticæ* and *H. Lewisi*, distinguished, as in the case of *Trypanosoma*, by their dependence on other and more highly organized animal types for their means of existence. Both of these species correspond with each other in the possession of an attenuate and highly flexible vermicular body, which is provided at one extremity with a single long locomotive flagellum. The species first named, *Herpomonas muscæ-domesticæ* (Pl. VII. figs. 6–8), was originally referred by Burnet to the genus *Bodo*, and, as its specific name implies, occurs as a parasite within the intestinal tract of the common House-fly, not unfrequently, under such conditions, being present in such vast numbers as to almost completely fill this passage. *Herpomonas Lewisi* (Pl. VII. figs. 9 and 10) is encountered under distinct and highly remarkable conditions. For the first, and so far only extant record of this species, we are indebted to Mr. H. G. Lewis, who discovered the animals as parasites of the blood in apparently entirely healthy Indian rats in the year 1877, and figured and described them, without any name, in the *Quarterly Microscopical Journal*, as simple flagellate organisms inhabiting the vital fluids of the above-named rodents. The specific name here associated with this type has been recently conferred upon it by the present writer in honour of its discoverer. As examined by Mr. Lewis, the bodies of these animalcules were found to be highly plastic or 'metabolic,' exhibiting every variety of contour, and, excepting for this circumstance, corresponding to a considerable extent with the *Ophidomonas jenensis* of Ehrenberg. No oral apparatus, endoplast, or other differentiated structures, have so far been observed. It was ascertained that the rats infested by these flagellate parasites possessed an entirely local distribution, tenanting a restricted portion only of the premises on which they were discovered. A minute flagellate type presenting a contour closely corresponding with that of *Herpomonas*, but

having a rigid acicular body, has been recently discovered by O. Bütschli within the intestine of the Nematoid worm, *Trilobus gracilis*. A social group of this species, bearing the accompanying title of *Rhaphimonas Bütschli*, is represented in Pl. VII. fig. 12.

Among the simpler forms of the Flagellata that are notable for their parasitic mode of existence, a prominent position must be allotted to the numerous representatives of the genus *Bodo*. Hitherto made to include a very heterogeneous assemblage of flagellate types, this generic group, as recognized by the present writer, comprises only those species which, while agreeing with *Cercomonas* in the possession of two flagella, the one anteriorly and the other posteriorly inserted, differ, independently of their separate habitats, in the circumstance, that the posterior flagellum is adhesive, and utilized for the purpose of anchoring the animalcule to the surface of contiguous objects; while in *Cercomonas* this appendage is non-adhesive and simply trailing. Under the conditions above named, the endoparasitic Bodos are mostly found adhering in more or less considerable social groups to the intestinal walls of their respective hosts, but are at the same time readily detached, and accommodate themselves for awhile to a natatory existence. Familiar examples of this genus are afforded by the *Bodo ranarum* of Ehrenberg, inhabiting the intestines of the common Frog; and by *B. helicis*, *B. julidis*, and *B. melolouthæ*, of Prof. Leidy, originally referred to the genus *Cercomonas*, and inhabiting respectively the alimentary tract of an American garden-snail, centipede, and cockchafer. Two forms, *Bodo hominis* of Davaine, and *B. urinarius* of Hunter, attach themselves to the human subject; while the *B. lymnæi* of Stiebel is similarly entertained by the common pond-snail. An illustration of a typical representative of the genus *Bodo*, *B. intestinalis*, will be found at Pl. VII. fig. 13.

No apparently mouthless forms possessing two anteriorly inserted vibratile flagella only, and thus referable to the Dimastigous section of the Flagellata-Pantostomata, have as yet been recorded as leading an exclusively endoparasitic existence. That division of the same section, however, which is distinguished by the possession of more than two flagelliferous appendages, and which may thus be conveniently distinguished by the title of the Pantostomata-Polymastiga comprises several highly noteworthy forms. First among these may be mentioned the several remarkable species for which Dujardin instituted the generic title of *Trichomonas*, and which were originally described by that investigator as possessing, in addition to two or three flagella, a more or less conspicuously developed fringe of vibratile cilia. It has been recently shown by

Stein, in connexion with *Trichomonas batrachorum*, which inhabits, in common with many other infusorial types, the alimentary canals of frogs and toads, that what was previously reported to be a supplementary fringe of cilia is actually a delicate frill-like undulating membrane, corresponding closely with that possessed by *Trypanosoma Eberthi*, and assisting, in conjunction with the three or four flagella, in the locomotive function. An illustration of this species, as recently delineated by Stein, is reproduced in Pl. VII. fig. 17. Two other species of the same genus, *Trichomonas vaginalis* and *T. limacis*, are associated respectively with the human subject and the garden slug. A second endoparasitic Polymastigous form, in which the flagellate appendages are no less than six in number, four being inserted at the anterior and two at the posterior extremity of the body, is represented by the genus *Hexamita*, instituted, in common with *Trichomonas*, by Dujardin, and containing in like manner three or four well-differentiated species. The typical representative of this genus, *Hexamita intestinalis* (Pl. VII. figs. 18–20), occurs abundantly in that prolific hunting-ground for parasitic organisms, the rectum and intestine of the frog, *Rana temporaria*, and has recently, in association with examples of this Batrachian dissected at the South Kensington Biological Laboratory, been the object of investigation by the present writer. As a result of this investigation, one or two points of interest concerning the deportment of these singular animalcules in the fluid medium they inhabit were placed on record. While usually described as essentially free-swimming organisms, it has been ascertained by the writer that they possess the faculty also of attaching themselves at will to associated objects, and of passing a temporarily sedentary existence. When first transferred to the field of the microscope, no such property is exhibited, the little creatures hurrying hither and thither in the most aimless and excited manner. Gradually, however, their movements grow more tranquil, till at length scarcely an animalcule is to be seen exhibiting its natatory capacities, all with rare exceptions having attached themselves to the organic débris or other suitable fulcra, through the medium of their two trailing posterior flagella, which possess a marked adhesive function. Sometimes, the entire lengths of these filiform appendages are utilized as organs of adherence, and sometimes only their distal extremities. Under these last-named conditions, a highly remarkable modification of the movements of this animalcule has been observed. Where the adhesion is effected by the entire length of the flagella, the motion of the body is simply oscillatory, the four anterior flagella being deployed and agitated without apparently any definite plan of

action. When, however, adherence is accomplished through the medium only of the terminations of the flagella, the body gyrates rapidly, and with rhythmical cadence, from right to left and left to right, such action causing, as shown in Pl. VII. fig. 18, the adherent flagella to become twisted on each other, while the four anterior ones describe elegant undulations round the animalcule's body. It would seem highly probable that the form described by Prof. Leidy under the title of *Trichonympha agilis*, found within the intestine of the American White Ant, *Termes flavicans*, and likened by the discoverer to the performers in an American ballet, whose chief attire consisted of long cords suspended from their shoulders, whirled in mazy undulations around them as they danced, represented a species of *Hexamita* observed under the conditions just described. Phenomena precisely identical with those just recorded of *Hexamita intestinalis* have been found by the writer to obtain also in the non-parasitic and marsh-dwelling species, *H. inflata*.

One more Polymastigous Flagellate form has to be included in the list of endoparasitic species. This type, described by Prof. Stein under the name of *Lophomonas blattarum* (Pl. VII. figs. 14 and 15), is found within the intestine of the common cockroach (*Blatta orientalis*), and is distinguished for its possession of a plume-like tuft of long vibratile flagella, which are produced from the anterior extremity of its otherwise naked and sub-ovate monadiform body. The chief interest attaching to this infusorium is connected with the fact, that among all other Flagellata (as so far known), it presents the nearest approach to the remarkable pelagic type upon which Prof. Häckel has recently conferred the name of *Magosphæra planula*, and which in its most characteristic adult state consists of free-swimming spheroidal colony-stocks of animalcules, whose anterior borders are densely clothed with long flagella, much after the manner of *Lophomonas*, but whose aggregate mode of development is comparable to that of *Syncrypta* or *Uroglena*. A second species, or well-marked variety of *Lophomonas*, having a more elongate and spirally striate body, has been recently described by O. Bütschli under the name of *L. striata*.

No animalcule referable to the Eustomatous section of the Flagellata can as yet be included among the strictly parasitic species, the only type remaining to be noticed before arriving at the Ciliate division of the present organic series being the species somewhat imperfectly described by Dr. J. H. Salisbury under the name of *Asthmatos ciliaris*, delineated in Pl. VII. fig. 16. This infusorial form, possessing locomotive appendages of two orders, consisting of an anterior tuft of vibratile cilia, from the centre of which is produced a single

terminal flagellum, may be conveniently relegated to the order of the Cilio-Flagellata, and is notable for its association with the human subject. Unlike the various forms so far enumerated, it is not, however, an inhabitant of the intestinal viscera of its selected host, but attaches itself to the passages pertaining to the respiratory system, being, according to its discoverer, an active agent in the production of one form of the infection known as 'Hay asthma' or 'Hay-fever.' The sputa, and mucous matter discharged from the throat and nasal passages of patients suffering from this ailment, were in every instance found to contain living examples of this animalcule, while they were entirely absent in the instances where the health was not so affected. The inhalation of dilute carbolic acid, or quinine, together with the direct application of the first-named medium, was found to yield immediate relief, and after a few days' perseverance in its application, to effect a complete and permanent cure. A microscopic examination of the mucous discharge after the application of either of the above-named remedies revealed the presence of the animalcules in a dead state only, thus affording additional evidence of their intimate connection with the irritation diagnostic of this somewhat remarkable ailment. While it would seem certain that the organism now under discussion represented the active principle in the cases investigated by Dr. Salisbury, it would not seem to apply in all instances. A form of *Bacteria* has been reported to exert a similar influence, its growth and irritating properties being checked by like remedies; while with many constitutions all the distressing symptoms of hay-fever are apparently produced through the mere contact of grass-pollen with the mucous membrane of the nasal passages.

Proceeding to an enumeration of the very considerable number of types belonging to the Ciliate section of the Infusoria that are characterized by their parasitic habits, the first and by far the most important place has to be allotted to the family group distinguished by the title of the Opalinidæ, every representative of which is, without exception, endoparasitic in some member or another of the vertebrate or invertebrate divisions of the animal kingdom. This essential and invariable endoparasitic mode of existence, combined with the circumstance that all the numerous generic and specific types are distinguished by the entire absence of an oral aperture or of the capacity of in any way ingesting solid food particles, has influenced many biologists to regard the Opalinidæ as a group of organisms entirely distinct from all the four orders of the Ciliata as now recognized, and by some, even, as an independent animal group, having no affinity with the Infusoria,

but exhibiting a closer relationship to the Scolecida and other mouthless endoparasitic worms. As now more familiarly known there can, however, be but little doubt that these animalcules must be regarded as specially modified and retrograde representatives of the ordinary Holotrichous Ciliata, which, by long exposure to an endoparasitic mode of existence, have in a parallel manner lost all trace of an oral system, and developed a capacity of absorbing the nutritious and protein-laden fluids in which they are constantly immersed, through the general surface of their cuticle. As originally instituted, the group of the Opalinidæ included only the single representative genus *Opalina;* recent research has, however, so extended the number of known species that it has been found convenient to separate them into four generic groups, each distinguishable by well-marked and highly characteristic structural modifications. In the simplest integer of this series, for which alone the original generic name of *Opalina* is now retained, structural differentiation is so rudimentary or obscure that its members were for a long while reported as being entirely devoid even of those two elementary histologic elements which, with scarcely an exception, are distinctly recognizable in every other known member of the infusorial world, and represented by the endoplast, or nucleus, and rhythmically expanding and contracting spaces known as contractile vesicles. That these simple *Opalinæ* are devoid of the structure last referred to has been confirmed by the latest and most exhaustive investigations; the same researches, as conducted by Engelmann and Ernst Zeller, have, however, revealed the fact that endoplasts, or nuclei, are not only invariably represented, but in many species occur in each adult individual zooid as innumerable very minute spheroidal bodies distributed at short intervals throughout the entire substance of the cortex, the animalcules in such cases, like some few other Infusoria and the Foraminifera, being essentially multinucleate. By some, it is held that this multinucleate structure of the *Opalinæ* militates substantially against their acceptance as unicellular organisms, and indicates their closer affinity to the multicellular or metazoic animal series. Neither here, however, nor in any other of the multinucleate representatives of the sub-kingdom Protozoa, is the slightest trace exhibited of a tendency of the body protoplasm to become subdivided into subordinate or cellular areas, as is essential to the composition of the metazoic body. It is nevertheless evident, that, in all these multinucleate forms a first step is made towards an acquirement of this higher metazoic organization, and that, it is in association with such abnormal types that the transition from one to the other of these two primary zoological groups is, if anywhere, to be successfully sought. It is an

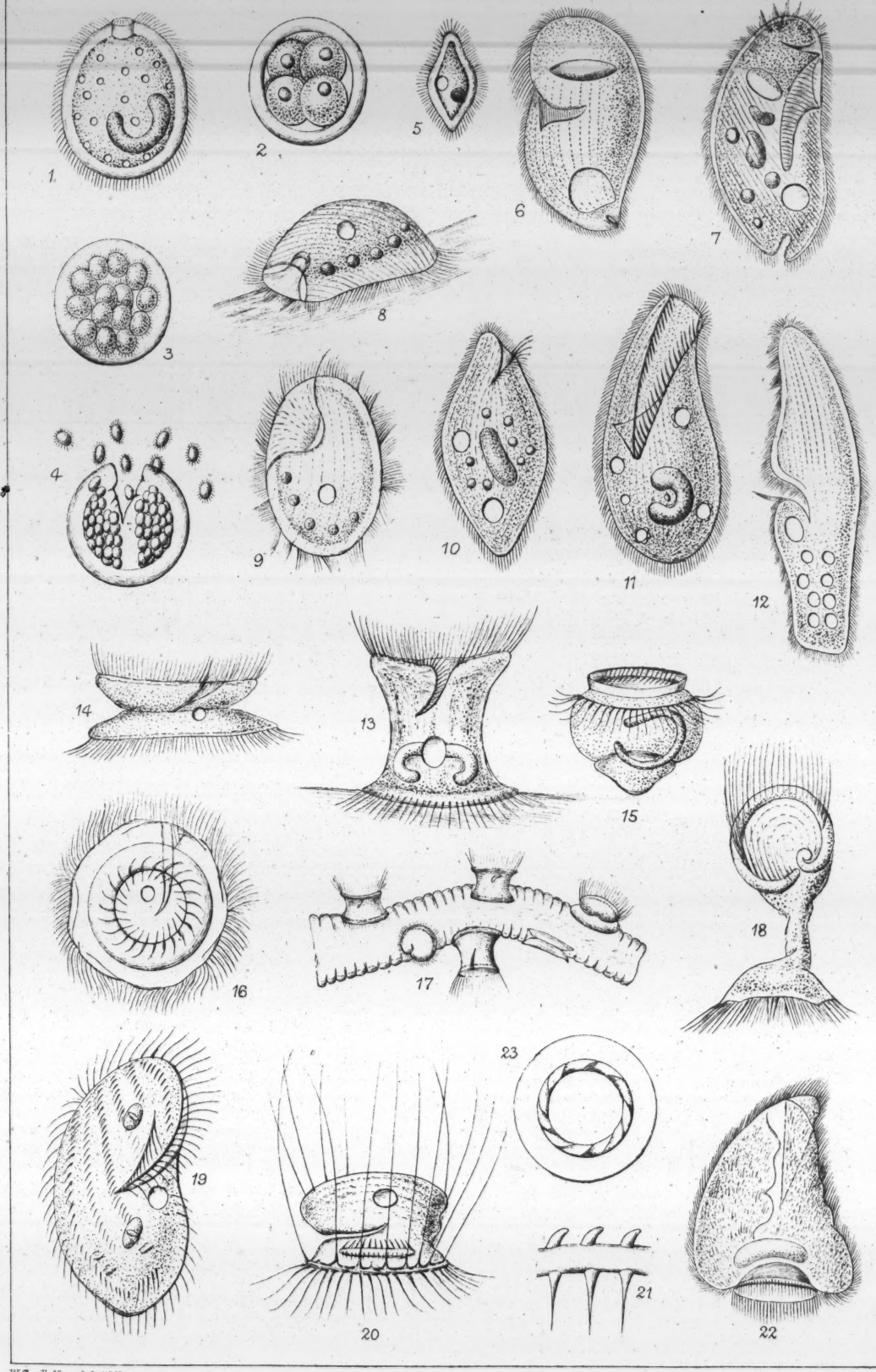
interesting circumstance in connection with the life-history of the multinucleate species of the genus *Opalina*, here referred to, that they commence existence with the possession of only a single endoplast or nucleus, and, after arriving at the full size or multinucleate condition, become subdivided by repeated fission into smaller and smaller fragments that possess finally only a single endoplastic element, each such ultimate fragment, after encystment and a more or less prolonged quiescent state, repeating the developmental cycle. The several species of *Opalina* proper occur invariably as endoparasites of the intestinal viscera of the tailed and tailless Amphibia; the most familiar type, as illustrated by *Opalina ranarum* (Pl. VII. figs. 21–25), being an almost constant guest of the common Frog (*Rana temporaria*).

The second generic group of the Opalinidæ, upon which Prof. Stein has conferred the title of *Anoplophrya*,—occurring abundantly as endoparasites of marine and fresh-water worms, molluscs, and other invertebrata,—exhibits a marked advance in complexity upon the one last described, there being in addition to a conspicuously developed endoplast, which mostly takes a band-like form, and is produced centrally through the entire length of the body, an equally distinct contractile vesicular system. Such system, moreover, is not represented, as in the majority of the Infusoria, by a single rhythmically contractile space, but by a number of such spaces, which are generally distributed in a single, or it may be a double, chain-like series, down one or both of the lateral borders. It is this monadiform modification of the disposition of the structures in question that doubtless leads to that lineal and canal-like development of this structure that is met with in certain other types, and which, indeed, by artificial pressure, may be produced in the forms now under consideration. A highly interesting circumstance, pertaining to the development phenomena of certain representatives of the genus *Anoplophrya*, is connected with the peculiar modification of the ordinary process of binary subdivision. In most instances, it happens that the animalcule so subdividing, becomes separated, either transversely or longitudinally, into two equal or sub-equal moieties. Here, however, it more often happens that a small and altogether unequal fragment becomes separated from the posterior extremity; while in occasional instances, such as *Anoplophrya prolifera* (Pl. VII. fig. 27), an endoparasite of a marine Planarian, a number of small fragmentary portions are developed simultaneously in the posterior region of the same zooid, and become separated off in consecutive order. As already recognized by various biologists, this reproductive phenomenon accords in a most remarkable manner with what obtains among the Tæniadæ and other Cestoid worms, in their so-called 'proglottid' reproductive phase. The two

remaining genera of the Opalinidæ, *Discophrya* and *Hoplitophrya*, yield yet additional structural modifications, suggestive of the affinities last cited. In the first of these, an adhesive organ, analogous to that exhibited by numbers of Cestoid and other endoparasitic worms, taking the form of a sucker or acetabulum, is developed at the anterior extremity; while in *Hoplitophrya*, a more or less complex series of horny hooklets is developed in the same region. These hooklets, as represented in *Hoplitophrya armata* (Pl. VII. fig. 26), a parasite of the Earthworm, at once recall to mind the structures having a like form and consistence common to a very considerable number of parasitic worms, and which are utilized by them in a corresponding manner for securing a firm hold upon the intestinal wall of their chosen host.

The animalcules referable to the Ciliate order of the Infusoria next to be mentioned, are distinguished for their ectoparasitic habits. Among these, the genus *Conchophthirus*, represented by three known specific types, is found associated with the mucous body-slime of various Mollusca. *Conchophthirus anodontæ* is thus, as its name implies, an ecto-parasite of the fresh-water Mussel; while *C. Steenstrupii* (Pl. VIII. figs. 8 and 9), is similarly attached to the Garden-Snail, *Helix hortensis*. A yet more remarkable, and in this instance, highly instructive infusorial form, is encountered in the type described by M. Fouquet, under the title of *Icthyophthirius multifilis*. This species (Pl. VIII. figs. 1–5) attaches itself to young trout, excavating more or less extensive depressions in the cuticular surface, and there multiplying to such an extent as to induce a morbid condition, and, unless checked in time, fatal results. The fish-hatching establishment in France recently suffered very severely through the attacks of this microscopic parasite. A remarkable fact is connected with the reproductive phenomena of this species; it is one of the very few ciliate Infusoria that are propagated by the subdivision of its mass into a considerable number of minute spore-like elements. While rare among the Ciliate class of the Infusoria, the sporuloid mode of reproduction is of common, and almost universal, occurrence among the comparatively lowly organized Flagellata.

Arriving at the order of Heterotricha, distinguished by their possession of a conspicuous series of larger adoral cilia, in addition to the finer ones which clothe the entire surface, the three genera, *Balantidium*, *Nyctotherus*, and *Plagiotoma*, are specially notable for their parasitic habits. Three out of five of the known species of the first-named genus occur in company with the Opalinidæ as endoparasites of the frogs and toads. One species, however, *Balantidium coli* (Pl. VIII. fig. 10), has been obtained from the colon of the human subject; while



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PARASITIC INFUSORIA.

the fifth form, *B. medusarum*, is described by Mereschkowsky as taking up its residence within the alimentary and radial canals of various small Medusæ, *Encope* and *Bougainvillia*, obtained from the White Sea. Among the Heterotrichous genera just enumerated, the highest physiological interest is undoubtedly attached to that of *Nyctotherus*. Its several representatives inhabit, as endoparasites, the intestinal viscera of various insects and myriopods, or in the case of *N. cordiformis* of Frogs and Toads. All are remarkable for a structural peculiarity which distinguishes them in a marked manner from all other known infusorial forms, such peculiarity consisting in their possession of a distinctly prolonged anal passage, which, produced from the posterior region towards the centre of the body, leaves but a little interspace between its termination and that of the conspicuously ciliated œsophageal passage produced inwards from the opposite or anterior extremity. But a slight prolongation of these two tubes is required to effect their junction, when, a complete alimentary tract in its most rudimentary form, as possessed by the Proctuchous Turbellarians, and other lower Metazoa, would be represented. Examples of this genus, as represented by *Nyctotherus velox* and *N. Gyoeryanus*, are delineated in Pl. VIII. figs. 6 and 7. It is a remarkable fact that this most highly organized infusorial type should be found side by side with the Opalinidæ, in which the alimentary system is present in its most rudimentary form, being, in point of fact, entirely aborted. This seeming anomaly is, however, satisfactorily explained in association with the circumstance that *Nyctotherus* has developed a taste for, and partakes freely of, the solid meats; while the Opalinidæ, as babes in evolution, restrict themselves to the fluid nutriment provided side by side in their chosen habitat. The genus *Plagiotoma*, represented by a single species, *P. lumbrici* (Pl. VIII. fig. 12), corresponds considerably with *Nyctotherus*, but is devoid of a conspicuous anal passage. It is found in the alimentary tract of the common Earthworm.

The Peritrichous order of the Ciliata, considering its extensive limits, comprises comparatively few true parasitic species, though, on the other hand, it includes a very large number that must be relegated to the category of Messmates, or Commensals. All the representatives of Peritricha are distinguished by the character of the ciliary system, which is limited to a circular or spiral wreath, developed in the anterior region, and conducting to the oral aperture. Those types, referable to this order, that claim immediate attention are comprised within the respective family groups of the Urceolariidæ, and Ophryoscolecidæ. The first-named of these, in-

cluding the genera *Trichodina*, *Urceolaria*, *Cyclochæta*, and *Licnophora*, are mostly distinguished for their ectoparasitic mode of existence, being in the majority of instances attached to the cuticular surface of the various invertebrate hosts they patronize, and apparently deriving their nutriment from the mucous and waste material cast off by these latter. Perhaps, indeed, it would be more correct to refer them to the Commensal series.

In order to enable these Urceolariidæ to retain a firm hold upon their elected fulcrums of support, the posterior region of the body is so modified as to constitute an adhesive disc or acetabulum, usually strengthened by a complex horny ring, over which its possessor maintains so complete a control that it can affix or detach itself at pleasure, and lead a sedentary or free-roving existence. Among the more familiar examples of this highly characteristic group reference may be made to *Trichodina pediculus*, illustrated by Plate VIII. figs. 13–17, which often occurs in abundance upon the body and tentacles of the fresh-water polypes *Hydra viridis* and *vulgaris*. Other species of the same genus, *e. g. T. Steinii*, *T. baltica*, and *T. scorpæna*, are found attached to the cuticular surface of respectively a fresh-water Planarian, a Baltic *Neritina*, and the Sea Bullhead, *Cottus scorpius*. In *Cyclochæta*, a singular modification of this same structural type, long, erect, setose filaments are developed in a crown-like manner round the body immediately above the acetabulum. The single known representative of this genus, *C. spongillæ* (Plate VIII. figs. 20 & 21), was recently discovered by Mr. W. H. Jackson infesting the cortical layer of the fresh-water Sponge, *Spongilla fluviatilis*, obtained from the river Cherwell at Oxford. *Licnophora*, while somewhat resembling *Trichodina* in outward form, is distinguished from it by the fact that, the anterior and posterior regions of the body are separated from one another by a stalk-like intermediate portion, while it is the right, and not the left limb of the adoral fringe of cilia, that descends into the oral aperture. Both of the two known species, *Licnophora Auerbachii* and *L. Cohnii*, are essentially marine, the former one, (Plate VIII., fig. 18), occurring on the Planarian, *Thysanozoon tuberculatum*, in the neighbourhood of Naples. A remarkable isomorphic or mimetic representative of the trichodinic structural type is afforded by the animalcule represented in Plate VIII., figs. 22 and 23, and upon which Mons. Claperede has conferred the title of *Trichodinopsis paradoxa*. This species, which occurs as a parasite within the intestinal and pulmonary cavities of various species of *Cyclostoma*, corresponds in all respects with the typical *Trichodinæ*, excepting that the entire surface of the body is clothed with fine vibratile cilia. This single circum-

stance renders it ineligible for admission into the ranks of the Peritricha proper, and indicates rather its Heterotrichous affinities. More correctly, perhaps, it may, like one or two other abnormal forms, be accepted as a connecting link between these respective orders.

The family of the Ophryoscolecidæ includes two genera, *Ophryoscolex* and *Entodinium*, which are notable for their occurrence as parasites within the first and second stomachs of various ruminants, such as sheep and oxen. Although first recognized as true Infusoria, and receiving their characteristic title, as here given, from Professor Stein, there can be but little doubt that they represent the forms originally discovered by MM. Gruby and Delafond, described by them in the '*Comptes Rendus*' for the year 1840, and there compared with Rotifera. All the several species are distinguished by the possession of an indurated carapace, frequently adorned with spinous processes; and both genera bear an anterior evertile and retractile adoral ciliary wreath, which in *Ophryoscolex* is supplemented by a second girdle of cilia, developed round the centre of the body. Unfortunately, no illustration of any representative of these very interesting genera has yet been published. According to the French authorities first quoted, these animalcules are found infesting the viscera of sheep in prodigious numbers. In five centigrammes of alimentary matter taken from the first and second stomachs (rumen and reticulum) of sheep, they found that no less than one-fifth of the total weight was composed of the bodies of these organisms. In the third and fourth stomachs (psalterium and abomasum), on the other hand, only dead and empty carapaces were met with, the softer nutrient endoplasm or parenchyma, having been dissolved out by the gastric juices. Upon the facts just recorded, MM. Gruby and Delafond argue, that the food supply of ruminants, though ostensibly of a purely vegetable nature, consists to a very considerable extent of lower animal organisms, which develope freely and with great rapidity in the first and second stomachs of their hosts, but are killed and assimilated on passing into the third and fourth stomachal compartments. The free Vorticellidan type recently described by Engelmann under the name of *Astylozoon fallax*, having two spinous processes at the posterior extremity, would seem to correspond so closely with *Ophryoscolex* and *Entodinum* in all essential structural details that its relegation to the same family group appears desirable.

But a single form out of the entire Hypotrichous order of the Ciliata (having vibratile cilia on the ventral surface only) has to be referred to the parasitic series now under consideration. This single type, the *Kerona polyporum* of C. G. Ehrenberg (Plate

VIII., fig. 19), closely resembles, in its generally flattened, bean-shaped contour, the cosmopolitan, free-swimming species *Chilodon cucullulus*. It is wanting, however, in the complex buccal armature that distinguishes that species, while the separate fringe of adoral or peristomial cilia is much more powerfully developed. The habitat of this animalcule is identical with that of *Trichodina pediculus*, it occurring as an ecto-parasite, often in vast numbers, on the body and tentacles of *Hydra vulgaris* and other fresh-water polypes. Like these Trichodinæ, it does not actually prey on the living tissues of its selected host, but contents itself with the waste material cast off from the cuticular surface, acting thus rather as a useful and efficient scavenger than as a parasite in the stricter and limited significance of that term.

EXPLANATION OF PLATES.

PLATE VII.

FIGS. 1 and 2. *Trypanosoma sanguinis*, Gruby. Parasite of blood of Frogs. × 600.

FIGS. 3–5. *Trypanosoma Eberthi*, S. K. Parasite of intestinal viscera of ducks and geese. × 800.

FIGS. 6–8. *Herpomonas muscæ-domesticæ*, Burnet, sp. Intestinal parasite of common House-fly. At Fig. 8, example dividing by longitudinal fission. × 650.

FIGS. 9 and 10. *Herpomonas Lewisi*, S. K. Parasite of blood of Indian Rats. × 800. At 11, blood corpuscle of Rat similarly magnified for purpose of comparing relative size.

FIG. 12. *Rhaphimonas Bütschli*, S. K. Intestinal parasite of nematoid Worm, *Trilobus gracilis*. × 600.

FIG. 13. *Bodo intestinalis*, Ehr. Intestinal parasite of Frogs and Toads. × 300.

FIGS. 14 and 15. *Lophomonas blattarum*, Stein. Intestinal parasite of Cockroach, *Blatta* (*Periplaneta*) *orientalis*, elongate and subspheroidal forms. × 500.

FIG. 16. *Asthmatos ciliaris*, Salisbury. Parasite of nasal and respiratory passages of the human subject. × 600.

FIG. 17. *Trichomonas batrachorum*, Perty. Intestinal parasite of the Frog. × 650.

FIGS. 18–20. *Hexamita intestinalis*, Dujardin. Intestinal parasite of Frogs and Toads. 18 and 19, attached; 20, free-swimming conditions. × 800.

FIGS. 21–25. *Opalina ranarum*, Purkinje. Intestinal parasite of Frogs and Toads. 21, multinucleate adult animalcule. × 100; 22, zooid dividing by transverse fission; 23, sporocyst with contained zooid; 24 and 25, young mononucleate condition.

FIG. 26. *Hoplitophrya armata*, Stein. Intestinal parasite of the Earthworm. × 100.

FIG. 27. *Anoplophrya prolifera*, Clap. and Lachm, sp. Intestinal parasite of marine planarian. × 100.

PLATE VIII.

FIGS. 1–5. *Icthyopthirius multifilis*, Fouquet. Ectoparasite of young Trout. 1, adult animalcule × 100; 2–5, sporular reproductive phases.

FIG. 6. *Nyctotherus velox*, Leidy. Endoparasite of myriapod, *Iulus marginatus*. × 100.

FIG. 7. *Nyctotherus Gyoeryanus*, Stein. Endoparasite of Water-beetle, *Hydrophilus piceus*. × 100.

FIGS. 8 and 9. *Conchopthirus Steenstrupii*, Stein. Parasite of Garden Snail. × 100.

FIG. 10. *Balantidium coli*, Stein. Intestinal parasite of the Human subject. × 100.

FIG. 11. *Balantidium entozoon*, Clap. and Lachm. Intestinal parasite of Frogs and Toads. × 100.

FIG. 12. *Plagiotoma lumbrici*, Duj. Endoparasite of the Earthworm, *Lumbricus terrestris*. × 100.

FIGS. 13–17. *Trichodina pediculus*, Ehr. Ectoparasite of the fresh-water Polype, *Hydra vulgaris*. 13–15, diverse contours assumable at will, × 300; 16, ventral view, showing toothed ring of acetabulum; 17, portion of tentacle of Hydra with *Trichodinæ* attached.

FIG. 18. *Licnophora Auerbachii*, Clap. Ectoparasite of planarian Worm, *Thysanozoon tuberculatum*. × 500.

FIG. 19. *Kerona polyporum*, Ehr. Ectoparasite of fresh-water Polype, *Hydra vulgaris*. × 200.

FIGS. 20 and 21. *Cyclochæta spongillæ*, Jackson. Parasite of fresh-water Sponge, *Spongilla fluviatilis*. 20, adult animalcule, × 200; 21, portion of denticulate horny ring, more highly magnified.

FIGS. 22 and 23. *Trichodinopsis paradoxa*, Clap. and Lachm. Parasite of intestinal and pulmonary cavities of fresh-water Molluscs, genus *Cyclostoma*. 22, adult animalcule, × 200; 23, horny ring of basal acetabulum.

ON THE OPINIONS OF VOLTAIRE AND LAPLACE REGARDING GEOLOGY.

By Prof. P. MARTIN DUNCAN, F.R.S. &c.

GEOLOGY, the science which investigates the successive changes that have modified the aspect of the surface of the earth, has passed through many phases during its long history. Depending much on the success of many other sciences, it has progressed or retrograded with them, and coming into opposition with religious tradition it has suffered during centuries. The history of geology has been closely connected with that of liberal intellectual culture in Europe, and the progress of the broad and very eclectic science has been synchronous with the development of civil and religious liberty. On the other hand, superstition and dogma have interfered with every branch of it, and the whole study had its age of mediæval darkness.

The science arose with the highest development of Grecian civilization, and made no small advance; and the Pythagorean doctrines, so full of truth regarding the phenomena of the former changes in the aspect of Nature, which have been handed down by Ovid, were the last and fullest expressions of the Grecian mind on geological subjects. No progress was made beyond them, and, indeed, they were considered heretical during the dark ages. From about 680 B.C. to the commencement of the sixteenth century of our era, no progress was made, and the published opinions of educated men regarding the earth, afford a melancholy instance of the subordination of the intellect. But light came at last, and where it might have been least expected by the student of general history. Fra Castero and Leonardo da Vinci expressed the more liberal opinions of Italian observers of Nature, and insisted that the fossil shells so constantly seen in the sub-Apennine strata, were once living, and that the Mediterranean Sea had once a larger area and had retired. Palissy inculcated correct views regarding fossils, seventy years afterwards; and his general belief in the former changes on the surface of the globe was that of the Greeks

modified to meet the peculiar views of ecclesiastical writers on the Deluge. Eighty more years were required to make any advance in the face of opposition, no longer from the old but from the new methods of religious thought and practice; and the end of the seventeenth century witnessed the development of more careful stratigraphical work, and of the grand theories of Leibnitz. The first half of the eighteenth century found geology a long way from the position which it occupied as a logical science at its close, when Hutton had elaborated his grand ideas of uniformity and continuity. Taking the age of Hutton as a stand-point, it is interesting to search out what was the nature of the common knowledge, regarding geology, amongst educated people before and about his time. What it was, may be well gleaned from the published works of two men of great genius, of very different kinds of minds, the one without any scientific animus, and the other devoted to exact knowledge. Both were distinguished Frenchmen, the one living before Hutton, and being the representative of the highest literary culture of an age of the greatest mental ferment; the other flourishing subsequently as the most distinguished mathematician of the Napoleonic age. They were Voltaire and Laplace.

Voltaire, detested as he was by the most powerful class in France, nevertheless attracted around him the advanced thinkers of his day; and his writings, so seldom read now-a-days, partly from prejudice and partly from the blatant impurity of many of them, indicate that he was unusually well read in all the subjects which were then attracting attention. He was an advanced representative man, at war with the priests and with the State when they endeavoured to override civil and religious liberty; his weapons were the keenest satire and the broadest humour, and they were none the less offensive because they were highly tempered in consonance with the manners and open vice of his age. A master of the art of ridicule, he often wore a mask of truth to render his shafts the more poisonous; and, indeed, it is often extremely difficult to know when he is serious or when joking. His scientific attainments were obtained, not in order that they should lead to further truths, but that they should be weapons against bad logic, the general disposition to accept every statement, made on authority, to be true, and against what he conceived to be unreasonable in Scripture. Take a chapter of his in his *Physique* as an example, which is headed, 'On the Changes which have occurred in our Globe, and on the Petrifactions which are pretended to be their Evidences:'—

'There are some errors which belong to the people, and there are others which only relate to philosophers. Perhaps the idea of so many physicists, that evidences are observable

over the whole earth of a general catastrophe, belongs to these last. They have found in the mountains of Hesse a stone which appears to be marked with the impression of a turbot, and on the Alps a petrified pike; they have therefore concluded that the sea and the rivers have flowed over the mountains. It was more natural to suspect that the fish, carried by a traveller, got stale, were cast away, and became petrified during a lapse of time. But this idea was too simple and not systematic enough. They say that they have discovered an anchor of a ship on a Swiss mountain; they do not reflect that people have often carried great bundles in their arms, and even cannon. It may be that they used this anchor to stop the bundles going down cracks in the rocks. It may be that they took this anchor from one of the little ports of the Lake of Geneva. It may be, finally, that the story is fabulous, and they prefer to assert that this was the anchor of a ship which was wrecked in Switzerland before the Deluge. The tongue of a dog-fish has some relation in shape to a stone, which has been called *Glossopètre*: this is enough to satisfy the physicians that these stones are as many tongues as the dog-fish left in the Apennines in the days of Noah.'

'The reptiles, when they are not in movement, usually assume the spiral shape; and it is not surprising that when they become petrified, the stone takes the shapeless figure of a Volute. It is again more natural that these are stones which formed themselves in spirals; the Alps and the Vosges are full of them. It has pleased naturalists to call these stones *cornes d'Ammon*. The fish called the nautilus, which has not been seen, and which was produced in the Indian Sea, is recognized in relation to them. Without too carefully examining whether this petrified fish is a nautilus or an eel, they conclude that the Indian Sea formerly inundated the mountains of Europe. Little shells have been seen in the provinces of Italy, of France, &c., which are stated to be originally from the Syrian Sea. I will not contest their origin; but may we not remember that the innumerable crowd of pilgrims and Crusaders carried its money to the Holy Land and brought back shells? Or would one rather believe that the Sea of Joppa and Sidon came to cover Burgundy and the Milanese? One might dispense well with the belief in one or the other of these hypotheses, and think, with many physicians, that these shells which are believed to have come from so far off, are fossils which the earth produced. We might, on the other hand, with more approach to reality, conjecture that there were formerly lakes in those localities where the shells are to be seen to-day. But whatever opinion or whatever error is inculcated, do these shells prove that all the universe has been capsized from top to

bottom? The mountains near Calais and Dover are of chalk; therefore formerly they were not separated by water. This may be, but it has not been proved. The rock of Gibraltar and near Tangier, is of the same kind, therefore Africa and Europe touched each other, and there was no Mediterranean Sea. The Pyrenees, the Alps, and the Apennines, have appeared to many philosophers to be the *débris* of a world which has changed its shape several times. This opinion, long maintained by the Pythagorean school and by others, affirms that all the habitable globe was once sea, and that the sea was long land.'

'This opinion has been more than once credited, by the examination of those beds of shells which are found heaped up in layers in Calabria, in Touraine, and other places, in earth situated far from the sea. Really there is a great appearance of their having been deposited during a long succession of ages. The sea, which has retired some leagues from its ancient shores, has returned, little by little, in other spots. From this almost insensible loss the right to believe in the ocean having covered the globe for a long time, is concluded. Frejus, Narbonne, and Ferrara, are no longer seaports: half of the little country of East Frisia has been submerged by the ocean; therefore, formerly, whales swam for ages over Mount Taurus and over the Alps, and the bottom of the sea was once peopled with men. This system of physical revolutions of the world has been strengthened in the minds of some philosophers by the discovery of M. de Louville. It is known that this astronomer went expressly to Marseilles, in 1714, to observe if the obliquity of the ecliptic was still the same as it had been determined by Pytheas nearly 2000 years before: he found it less by 20′. That is to say, according to his views, the ecliptic had approached the equator $\frac{1}{3}°$, which proves that in 6000 years the approach would be an entire degree. This supposed, it is evident that the earth, besides its known movements, has another which makes it turn on itself from one pole to the other. It would happen that in 23,000 years the sun would be over the equator for a long period, and that in a period of about two million of years, all the climates of the world would have occurred consecutively, in the torrid zone and in the glacial zones.'

'Why, they say, be frightened about a period of two million of years? There are probably longer ones between the reciprocal position of the stars. We know already of a movement of the globe which is accomplished in more than 25,000 years, and it is that of the precession of the equinoxes. The passing away of thousands of millions of years is infinitely less in the eyes of the Eternal Architect of the universe, than are the turnings of a wheel in the twinkling of our eyes. This new period imagined by the Chevalier de Louville, and main-

tained and corrected by many astronomers, recalled the ancient researches of the Babylonians, transmitted to the Greeks by Alexander, and preserved for posterity by Ptolemy in his *Almageste*. The Babylonians pretended at the time of Alexander to have astronomical observations for 400,300 years. The attempt was made to reconcile the calculations of the Babylonians with the hypothesis of the revolutions in the millions of years; and finally, some philosophers concluded that each climate had its turn—now at the pole, now on the equator, all the seas having changed their places.'

'The marvellous, the vast, the grand mutations, these are the matters which are sometimes pleasing to the imagination of the most wise. Philosophers want the great changes in the scenes of the world, just as people do when they go to the play. From the stand-point of our existence and of its duration, our imagination soars up in the midst of millions of ages to see with pleasure Canada under the equator, and the seas of Nova Zembla upon Mount Atlas.'

This very considerable jumble of shrewd common sense, ignorance, and unreasonable opposition to inevitable conclusions, indicates, however, what were the common opinions of the day about the great succession of changes. There is some lively sarcasm at the service of the geologists who derive great theories from little facts, and it is interesting to find so great a thinker opposed to the Pythagorean doctrines. Yet the reasoning regarding the former connexion of England with France, and of Spain with Africa, is very ignorantly set aside. The common knowledge of the day was thus in advance of the critic; and it is interesting to note the ancient date of the truth of the continuity of sedimentary strata, except under the aspect of thinning out. The petrifactions and fossils were even in Voltaire's day a great trouble to the unscientific, although their true nature had been proved; but it is evident that the common knowledge of the day was in favour of the spontaneous origin of fossils and odd-shaped stones—the earth grew them.

These are ideas which are common enough, even in these days of educational progress. The mistake relating to the movement of the ecliptic is interesting, because it shows how thoroughly what may be called Astronomical Geology had taken hold of the minds of the educated classes, thanks to the great French mathematicians, who had followed our Newton. The question of the possibility of any great variation in the inclination of the polar axis to the ecliptic, has been of late greatly agitated, and the physicist declares against the possibility, whilst not a few geologists assert that the phenomena they perceive to have taken place, cannot be explained by any other method. It is interesting, then, to find these questions

regarding changes of climate so fully developing themselves. There is no doubt that Voltaire knew much which he did not care to advance in this chapter; but it is a characteristic of his style to sacrifice everything to the opportunity of an onslaught against what he considered unreasonable or dogmatic. Nevertheless, as will be noticed further on, Voltaire never grasped the possibility of any secular changes in the relative level of land and sea floor; subsidence on a grand scale does not appear to have been a notion within his imagination, although he appears to accept it as a cause of the production of some islands. In one essay he is sincerely uniformitarian in his views—the subject still being on the changes which have occurred on the globe. He says,—

'When one's own eyes have seen a mountain advance on to a plain—that is to say, an immense rock of the mountain become detached and cover some fields, an entire castle sink into the earth, a river swallowed up, and which comes forth from its abyss further on, the indubitable marks that a vast mass of water formerly inundated a country now inhabited, and a hundred vestiges of other revolutions, one is more disposed to believe in the great changes which have altered the surface of the earth, than a Parisian lady, who only knows that her house is built where there was formerly tilled ground, may be. But a Neapolitan lady, who has seen the subterranean ruins of Herculaneum, is less a slave to the prejudice which would have us believe that everything has always been as it is to-day.'

'Was there a great conflagration in the days of a Phaeton? Nothing is more likely: but it was neither the ambition of Phaeton nor the anger of Thundering Jove which caused the catastrophe. Similarly, in Lisbon in 1755, it was not the fires so frequently lit by the Inquisition which attracted Divine vengeance, which lit the subterranean fires, and which destroyed half of the town. For Mequinez, Tetuan, and considerable hordes of Arabs were more maltreated than Lisbon, and there was no Inquisition in those countries.

'The island of San Domingo, lately quite ruined, was not more displeasing to the Great Being than the island of Corsica. Everything is subject to eternal physical laws. The sulphur, the bitumen, the nitre, the iron, enclosed in the earth have thrown down a thousand cities by their mixtures and explosions, have opened and shut thousands of cracks, and we are threatened daily by accidents which depend upon the manner in which the world has been made, just as we are menaced in many countries during the winter by starving wolves and tigers. If fire, which Democritus believed was the first principle, has ruined one part of the earth, the first principle

of Thales, water, has also produced great changes. Half of America is still inundated with the ancient deposits of the Maragnon, of the Rio de la Plata, of the St. Lawrence and the Mississippi, and of all the rivers which increase in volume, thanks to the melting of the eternal snow of the highest mountains of the world, and which traverse the continent from one side to the other.'

'These accumulated deluges have produced great marshes almost everywhere. The neighbouring districts have become uninhabitable, and the soil which ought to have been fertilized by the hand of man, produces fish. The same thing has happened in China and in Egypt, and a multitude of centuries have been consumed in making canals and in draining the ground. Add to these long disasters the irruptions of the sea, the countries it has invaded or deserted, the islands it has detached from the continents, and it will be found that more than 80,000 square leagues have been wrecked from east to west, from Japan to the Atlas.'

Voltaire thus, with some accurate geographical knowledge, and with considerable point, argues against the popular notion of his day, of the persistence of all things. He then proceeds to argue in favour of, and against the Atlantis, and advances the evident former union of the Grecian Isles and Sicily with their mainlands as a suggestive proof of the subsidence of the land between the mainland and the Canaries. He states—on what authority is doubtful—that the Atlantic has but little depth between the Canaries and the mainland.

Voltaire's onslaught on Burnet is, of course, racy. He notices that 'one author, who has become more celebrated than useful by his theory of the earth, has pretended that the deluge wrecked the earth, and formed rocks and mountains, and put all into supreme confusion, and that one only sees a ruined world;' and that 'the author of another theory not less celebrated, sees nothing but arrangement, and decides that without this deluge this harmony would not have existed. Both consider the mountains to have followed the universal inundation. Burnet, in his eighth chapter, assures us that the earth before the deluge was regular, uniform, without mountains, valleys, and seas. The deluge did all that, and therefore we find *cornes d'Ammon* in the Apennines.' He then jeers at Woodward with great success, and remarks, 'The greater number of the philosophers have placed themselves without ceremony in the place of God; they think they can create an universe with a word.'

Voltaire asserts his right to examine, in consonance with the laws of probability, if this globe has ever been, or ever will be, so absolutely different from what it now is. He considers that people have only got to use their eyes. He examines the

mountains stated to be a disorderly mass of ruins of an ancient world, '*dispersé ça et là*,' like the ruins of a bombarded town, and finds them, on the contrary, arranged in definite order from one end of the universe to the other. 'It is, in fact, a chain of high and constant aqueducts, open in many spots, and giving that space to the rivers and arms of the sea which they require to irrigate the earth.' Noticing Burnet's confusion-dogma again, he remarks that 'the mountains serve as reservoirs for rain, and are the sources of rivers, and no one can fail to see in this pretended confusion the wisdom and benevolence of God.' He proceeds to state 'that every climate has its mountains, and that they are necessary for the machinery of the world. Animals could not live without them, for life cannot be without water. Water is evaporated by the sea, and is thus constantly purified; the winds carry it to the summits of the hills, where it is precipitated, and it is shown that there is a relation between the supply and the size of the rivers.' He does not believe in the Louville doctrine, and states that if it were true, the mountains would find themselves still in the same places, and that he cannot find proofs that the Alps and Caucasus have gone, even bit by bit, to Caffraria. He states that the 'bed of the ocean is a hollow, the remoter from the shore the deeper is it. There is not a rock in the open ocean except some islands. But if there were ever a time when the ocean has been on our mountains, if men and animals have ever lived in the hollow which now serves for the floor of the ocean, could they have existed there? From what mountains could they have received rivers? The world then must have been something quite different from what it is now. And how could this globe turn on itself, having one-half hollowed out and the other half high above, and surcharged with an ocean? How did this ocean manage to hold on to the mountain without flowing into the immense bed which Nature had hollowed out for it? The philosophers who make a world, only manage to make a ridiculous one. There is, then, no "système" which can give the least probability to this idea so generally diffused, that our globe has changed its aspect, that the ocean has been long over habitable earth, and that men have lived formerly where porpoises and whales do now. Everything which vegetates, and that which is alive, does not change; every species has lasted invariably as the same. It would be very strange that a millet-seed should retain for ever its nature, and that the whole globe varied in its own.' He considers the formation of the Mediterranean and its water supply, and pooh-poohs the philosophers who stated that it has been formed by an accident, stating that it has always been in its place, and that the fundamental constitution of this universe

has never changed. Further on he attacks the people who are affected by the petrified turbot and pike already noticed, and says that they argue against sound physical reasoning; and adds, 'The love of the marvellous renders systematic philosophy childish; but Nature seems to please itself in uniformity and constancy, although our imagination revels in great changes.' This excessive uniformitarianism, a little contradictory to expressions used but a few lines back, is utilized by Voltaire in the next sentence. He states that Scripture tells us there has been a deluge, but there does not appear to be any other 'monument' of it than the memory of a terrible prodigy, which warns us in vain to be just.

In noticing the dendritic markings on such stones as agates, some kinds of marble, and flints, Voltaire states that 'it was not a tree or a house, or a man's face, which left an impression on the little stones at a time when they might have been soft or fluid, and that these are instances of an empire of whose power there is no doubt.'

Then he makes a jumble between dendrites and the true impressions of plants. He says, 'To say that the imprints of leaves of trees, which only grow in India have been seen on these dendrites, is it not to advance a matter barely proved? Does not such a fiction follow suit on the romance, imagined by some people, that the Indian sea came formerly into Germany, Gaul and Spain? The Huns and the Goths certainly came there, but the sea does not travel like men. It gravitates eternally towards the centre of the globe; it obeys the laws of Nature; and if it could have made this trip, how could it have brought the leaves of India to deposit them on the agates of Bohemia?' He insists upon this logic, and says that it enables him to nullify the opinion that the little fishes of the most distant seas have come to inhabit the quarries of Montmartre and the tops of the Alps and Pyrenees.

Voltaire believed that Nature amused herself in forming as many kinds of stones as animals: she produced them in the resemblance of parts of organisms, or twisted them in spirals, which some people have foolishly called *Cornes d'Ammon*. With regard to the knotty subject of the production of flints, he wants to know 'What stony juice made the thousand kinds of flint? How is it that in many of our countries not a single flint is to be seen, whilst others are covered with them? Why is it that in America, near the Amazon, none are to be found for 500 leagues? Sometimes enormous flints are to be found in the middle of fields, and close to them are others, not an inch in diameter, some are even only two or three lines across. Their specific gravity differs; in some it is that of iron, and in

others rather more. However heavy, opaque, or smooth, a pebble-flint may be, it is drilled with holes;' and Voltaire thinks that insects might occupy the million holes. 'It is an assemblage of homogeneous matters which produces an indestructible mass to the hammer. It is vitrifiable by long-continued heat in a furnace, and then it is observed that its constituent parts are a kind of crystal. But what force has joined these little crystals?'

'The attraction demonstrated to exist between the sun and the planets, between the earth and its satellite,—does it act between all the particles of the earth whilst it penetrates to the centre of the whole globe? Is this the first principle of the cohesion of bodies?' Voltaire notices that the Alps and other mountains contain many kinds of rocks, and addresses himself to show that a small quantity of vinegar will dissolve in the laboratory small portions of some of the rocks; therefore Hannibal did dissolve an escarpment which stopped the way; he states, in fact, that every child can make the experiment of Hannibal.

Ever wrong, from his inability to grasp the evidences of upheaval and subsidence in relation to a datum line, Voltaire argues against the value of shells found remote from the sea proving any former aspect of nature. He believed that what were found were of fresh-water kinds, and remarking on the immense number of snails that infest parts of France, demurs to accept the theory of Indian migration. But he makes a remark which will interest some amongst us: 'They discovered, or thought they did, some years ago, the bones of reindeer and of hippopotamus near Etampes; and hence it was concluded that the Nile and Lapland were formerly on the road from Paris to Orleans. But we may rather suspect that some lover of the curious formerly had these skeletons in his cabinet. A hundred parallel examples invite us to examine before believing.'

Voltaire wrote also on the shells of Touraine, a criticism of Buffon's really philosophical views of change in Nature, and indulged in some very remarkable observations on the nature of the scale of animated beings, and about corals.

Laplace, so well known to us by his great labours regarding the figure of the earth, treats the geology of his day — the early part of this century—in an astronomical manner. He antagonized some of the vulgar errors regarding the great depth of the ocean which were put forward in his day, and which lasted until a comparatively late date. His proofs were mathematical and related to the laws of the rotation of homogeneous and non-homogeneous spheres of the dimensions of the earth. It was believed that the ocean was not to be fathomed in many parts, and even the continuity of the sea, through the whole mass of the globe, from one side to the other, had its advocates.

This was the result of soundings taken with every possible difficulty and liable to every possible error, and of the extremely lively imaginations of the physical geographers of the day. But Laplace showed that the depth of the sea is a small fraction of the difference of the polar and equatorial axes of the globe, and of course his deductions did not relate in any way to measurements by soundings. It was a remarkable statement, and has been enhanced in value by the deep-sea soundings of late years. Taking the difference of the axes to be, in round numbers, 26 miles, the average depth of the great ocean is from 2000, 2400, to the extreme of 3000 fathoms, the middle number being the probable correct average. This gives a depth of nearly three miles to the ocean; and it is rather under one ninth of the standard mentioned.

According to Laplace, the oceans occupy irregularities of the surface of the earth; and mountains, table-lands, and the deep valleys, may be considered irregularities when curvature of strata, and great anticlinal and synclinal axes are to be seen amongst them. The depth of the bases of mountains, calculated from the direction of the downward curvatures of the lowest strata and the possible depth of the strata beneath the sea, gleaned from the dip of coast-line strata, appear to be enormous, and especially to those observers who are untrained. But the distinguished mathematician stated as his opinion that the irregularities of the surface of the earth and the agents which have to do with them, are at, and act at, a very slight depth below the surface. That is to say, relatively to the great bulk of the globe and its diameter, the space immediately beneath the surface, which has been affected by internal movements during the ages since the present irregularities have existed, is small. The depth of the earthquake focus, of the hypothetical volcanic reservoirs, and of the movement resulting in tangential thrusts sufficient to produce the grandest oceanic and continental geosynclinals and geanticlinals, or the minor anticlinoria and synclinoria of mountain-chains is slight, according to Laplace, writing in the second decade of this century. The great globe is quiescent within, and any energy still lingering on, is very superficial, or is antagonized by the enormous internal density of the mass. The energy is heat, and that was of course acknowledged by Laplace. The amount of knowledge of stratigraphical geology was not inconsiderable in his day, and the relations of the intrusive to the sedimentary rocks were understood; moreover, there was a belief in the primitive nature of granites and such highly crystalline rocks. But these and their great curvatures must have all appeared like filmy wavelets on the vast globe, to the great mathematician. It is doubtful, however, whether this was common knowledge,

for it is not consonant with the catastrophic ideas which prevailed so late in this century. It was certainly a foreshadowing of the opinions of the advanced school of the present day, which denies that any palpable amount of temperature has existed at the surface, conducted from below, since life has been in the sea and on the land; and which asserts that the hot spring, the volcano, and the measurable heat in mines represent so much available kinetic energy, the result of rock movement and earth contraction. The primary energy bears a very slight relation to the size of the globe and has not been exerted on a grand scale since the present density has existed. The exceeding slowness of the great crust movements appears to have been in relation to the comparatively small depth of surface affected by them. Laplace does not indicate the depth implicated beneath the surface in the successive movements which we may assume so altered the aspect of nature as to originate and terminate physical geographies of old—geological formations: but it may be now assumed that the movements must have diminished in intensity from the surface downwards, and that their sum total since the laying down of the Laurentian sediments has been vast. There is a proof of this which has not been much considered. Endeavour, in the mind's eye, to flatten out the curvatures of the strata of the Himalayas and Alps, and of the Continent to the north and south, treat the curvatures of the Scandinavian hills, the Oural and the Andes, in the same manner, and consider the vast space once occupied by the horizontal strata. Do the same in respect to mining districts, from off which mountains have been worn and washed away, and extend their folded and contorted strata, in the imagination, until they represent the breadth and length of their original deposition. There are no vast, gaping fissures, but, with the exception of some few lands, every part of the great continent is formed by sub-rock which once, before it was exposed to tangential thrust and curved, covered at least twice its present area. I know of no other subject in relation to geology, which impresses the mind so much regarding the secular contraction of the globe, since the first appearance of life. Laplace insists that the earth was primitively fluid, and that the present shape of the surface of the earth, covered more or less as it is by sea, is in accordance with the laws of equilibrium, a slight deformity only existing. He then proceeds to prove that the density of the layers of the earth increases from the surface to the centre, and that these layers are nearly regularly arranged around the centre of gravity. All this led up, in after years, to the knowledge that the density of the earth is greatest under the ocean, and least under the mountain-chains, that of the plains being intermediate; and also that the centres of figure and of gravity do not correspond.

THE AUGUST METEORS.

By W. F. DENNING, F.R.A.S.

THE August shower of meteors forms one of the most attractive and important of the annual phenomena witnessed by astronomers, and the display is awaited every year with considerable interest—not only by a large section of habitual observers, but by many persons who have their attention called to it in a mere casual way by the frequency and brightness of the meteors. For on the 10th of August, if the night is clear and the moonlight not very strong, a person cannot be long in the open before his curiosity is excited by numbers of these 'falling stars' which, he will notice, travelling swiftly athwart the sky, and leaving lines of phosphorescence along their paths. It is, however, not the business of the ordinary gazer to regard such occurrences with more than a passing interest, and he simply watches their progress with a feeling almost amounting to utter indifference. But it serves to while away a leisure hour and to give rise to some curious speculations as to the origin and end of the transient objects which now and again come before his view. The case is different with the scientific observer. He has a practical interest in the phenomenon, and zealously endeavours to record its more remarkable features as they become successively presented, and to watch with increasing diligence its further development in the later hours of the night, remembering that his notes must hereafter have some value in the general comparison of results.

Quetelet's catalogue of observed meteor showers embraces a large number which obviously belong to the August period, but the majority occurred during the present century. This cannot be ascribed to an increasing activity of the meteor stream. It is at once explained by a greater assiduity of observation, and by the fact that the subject is considered of more importance than formerly. Hence in more recent years the shower

has been diligently looked for by many observers; and the result is that we find a large number of records of its displays. In former years it was comparatively neglected. The uncertainty attached to the whole subject rendered it unattractive, for there seemed little likelihood that it would ever become an important branch of astronomy, or yield any valuable results to the patient observer of its nightly displays. Thus we find, amongst historical records, only a few scattered references to this shower, and we are led, at first, to the inference that it was only rarely visible in consequence of the meteors being slightly dispersed over the orbit in former years. But the irregularities in the dates of its former apparitions may safely be ascribed to other causes than a physical peculiarity of the shower itself. The lack of interest in the subject would cause it frequently to be disregarded. Many of its exhibitions would pass wholly unobserved. Indeed, it would only be described when it recurred with such striking intensity as to force itself upon the attention as a celestial event of considerable interest. It appears to have been thus observed in the following years :—

811, July 25	1243, August 2
820, July 25–30	1451, August 7
824, July 26–28	1709, August 8
830, July 26	1779, August 9–10
833, July 27	1781, August 8
835, July 26	1784, August 6–9
841, July 25–30	1789, August 10
924, July 27–30	1798, August 9
925, July 27–30	1799, August 9–10
926, July 27–30	1800, August 10
933, July 25–30	

Between 811 and 841 it furnished a succession of brilliant displays at the end of July. Then there occurred a break until eighty-three years later, when it several times reappeared with similar splendour. A wide interval of more than three hundred years brings us to the year 1243, when it seems to have been again recognized, after which, until 1709, there is only one other observation of the shower (in 1451). During the last hundred years it has, however, been frequently observed, though many of the recent displays cannot be compared with those of ancient times. The intermittent and rare character of the shower as it existed between the tenth and eighteenth centuries proves that few returns were of a sufficiently imposing nature to be recorded, and that possibly the conditions were opposed to its appearance. If the meteors of the orbit during that period were condensed in the region of their derivative comet, then we can understand the singular paucity of observa-

tions. The Earth, as it passed the node, would year after year encounter no meteors until the perihelion approach of the cluster, when possibly the display may have occurred in the day-time, and been of such brief duration as entirely to elude detection.

The entry of this stream into the solar system probably dates back to a very remote antiquity—for there are several circumstances which conspire to prove that such must have been the case, and that it preceded, by many ages, the apparition of the Leonids, Andromedes, and some of the other periodical meteor-showers. The fact that it constitutes an unbroken ring leads to the inference that it must have existed from the earliest times in order to bring about so complete a dispersion of its particles, for on its first introduction, as a comet, to the Earth, it is to be assumed that it formed a condensed mass like the Leonids, and only appeared as a meteor-shower when the comet returned to perihelion. A very slight difference in the periodic times of the individual meteors following the nucleus must have eventually distributed them (by its cumulative effects) along the entire orbit. In other words, the original group must have undergone a process of lengthening out, until, at the present day, it consists of a parabolic zone of meteoric pellets, through which the Earth passes annually on August 10. Moreover, the radiant point of the shower often fails to become sharply defined. Several concentric streams of similar meteors appear to diverge from the region about η *Persei*, and their physical identity is unquestionable. They are merely the deflections or offshoots from the original system which must be greatly disturbed and contorted as the Earth annually intersects it. The full effects of these perturbations can hardly be estimated: many of the particles must be diverted into new orbits, and one of the results upon the main stream may be a constant widening out, so that the apparent duration of the shower must go on increasing. It now actively extends over at least eight nights; hence the width must exceed 10,000,000 miles. And some diminution in its intensity must occur at each return, unless there is a source of compensation for the expenditure of its materials upon the Earth. But though many millions of the atoms are annually consumed in our atmosphere, the effect of the thinning out will be very gradual in making itself appreciable, for, as compared with the vast assemblage which constitutes the main ring, the proportion which encounters the Earth is small indeed. As it is enveloped in the stream comparatively few of the meteors are actually intercepted. By far the greater number pass by untouched. If a ball is thrown up in a thick shower of rain it will only encounter a few drops. This may be taken as an illustration. The Earth, with its diameter of 8000 miles, can

only meet with a few meteors in its rapid flight through a zone exceeding 10,000,000 miles in width.

The period of the August meteors is uncertain. Their distribution appears to have been so effectual that the element cannot be determined. Some years give plentiful showers, but there have been no decided traces of regularly recurring maxima, as in the case of the Leonids. This may possibly be explained by the fact that the period is a long one, and would not become defined until after centuries of research. Comet III. 1862, which shows an exact resemblance of orbit to this system, was computed by Oppolzer to have a period of 121·5 years; and as there occurred a fine display of the August meteors in 1863, we cannot anticipate its periodical return until about 1964, if the calculations are reliable.

The August Perseids have been more frequently observed than any other system of shooting stars, from the fact that they are visible every year with more or less distinctness, and that, as an annual shower, they cannot be surpassed by any other display. The two celebrated streams of November 13 and 27, occasionally giving rise to showers of great splendour, are periodical in character, though it is extremely probable that a few of their meteors encounter the Earth at the regular return of the dates; notwithstanding that they may elude observation in consequence either of moonlight or cloudy weather, which, indeed, generally offers some impediment to success. But the August meteors recur annually with considerable intensity, and had attracted attention at a very remote epoch, though the phenomenon was not systematically studied until later times. It was reserved for Heis at Aix-la-Chapelle to more thoroughly investigate the meteors of August, for the previous observers, though they had ascertained the fact that the month was notable in this respect, had yet neglected to obtain any important data with regard to the number or directions of the meteors seen. Schmidt also, at Bonn, began assiduously to devote himself to this special line of inquiry. The particular night in August when the meteors were most plentifully distributed was found to be the 10th, though the numbers were subject to considerable variations in different years. Schmidt, from an average of several years of observations, gave the following as the horary number of falling stars for one observer. His results are compared with a similar average derived by Major Tupman and the writer from observations in 1869–71 and 1877–80 respectively :—

Date.	Falling stars in one hour. Schmidt.	Tupman.	Denning.
6 August.	6	36	13
7 „	11	37	23
8 „	15	45	26
9 „	29	—	44
(max.) 10 „	31	59	71
11 „	19	53	38
12 „	7	27	24

Schmidt's figures are very small and much below the numbers found in recent years. But the averages in the table are not thoroughly reliable, inasmuch as they are based upon only a few years' observations. A longer series might give a closer comparison, but it is seldom that the results of independent observers agree within small limits. There are differences in vision, modes of observation, and in position, which must obviously affect the numbers to no small degree; and the intermittent character of the meteor shower itself must give rise to discrepancies which cannot at first sight be accounted for. The horary number of meteors on August 10 may vary, according to Heis, from 160 (in 1839) to 24 (in 1867). During the last ten years the writer has found little variation in the intensity of the annual returns when the conditions of weather and moonlight are fully taken into account; and there is no question that some of the variations ascribed to the shower have no real existence, but are to be explained by the differences referred to above.

A fair comparison cannot be instituted between the horary numbers found by observers, unless the observations, from which the values are deduced, are made, in each case, at similar hours of the night; for shooting stars, though often plentiful after midnight, are comparatively scarce in the evening hours. This is readily explained by the fact that the principal radiant points of the showers are massed together in the eastern region of the sky where the Earth's orbital motion is directed, and it is obvious that in the evening hours, when the altitude of many of them is very low, and when others have scarcely appeared above the horizon, their operation is in a great measure restricted, so that only a feeble indication of their displays is perceptible at such a time. The case is entirely different at a later period of the night, when the constellations in which the several radiant points are situated have ascended high in the sky, and are in fact so placed that they may be seen to the greatest advantage. The August Perseids are always best observable in the morning hours, for the radiant point is very low on the horizon soon after dark, and a person who persistently watches it during the night, will find, with increasing

elevation of the radiant, a corresponding increase in the hourly number of meteors. In 1877, at Bristol, the eastern sky was persistently watched between $9^h\ 30^m$ and $14^h\ 30^m$, when 354 meteors were seen; and though the horary rate before 11^h was only 47, it rose to about 80 during the last half of the watch. Indeed the number of meteors observed at the end of the watch was more than double the number recorded at the beginning of it. Thus it is apparent that the most favourable time for such observations is in the morning hours, and though it is generally inconvenient for amateurs to extend their vigils thus far, the importance of doing so cannot be too strongly insisted on.

A typical feature of the Perseids is to be found in the streaks which frequently mark their course (fig. 1), and serve an extremely useful purpose in enabling the directions to be registered with great accuracy. The theoretical velocity of these meteors is thirty-eight miles per second, so that they belong to the swiftest class of such bodies, and, as such, would be individually re-

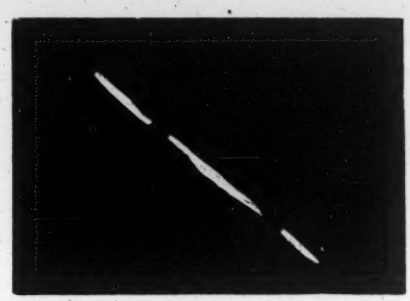

FIG. 1.—Broken Streak of a Perseid in *Pegasus*, Aug. 11, $11^h\ 10^m$.

corded with much difficulty, were it not for the special feature referred to. Their very rapid transient flights would baffle the observer as he stood endeavouring to retain the exact points of beginning and ending; and in the majority of instances he must absolutely fail to get nearer than a mere approximation. Only in cases where the meteors sped from one star to another, or in courses parallel to closely adjoining stars, could the paths be truthfully reproduced on his map. But fortunately for such investigations, we have no such difficulties to encounter. The phosphorescent line almost invariably projected on the sky by the nucleus as it rushes along, remains to guide the eye in fixing its position. It is the authentic signature of the meteor gone before, and during the brief span of its endurance the observer knows how to utilize it. It is seldom these streaks last longer than three or four seconds, though in exceptional cases of Perseid fireballs they have lingered several minutes. The writer found the average

1·8 seconds from many observations in August 1880; and the most frequent duration is about two seconds. All the brighter meteors of the shower display them. Mr. Henry Corder, of Writtle, has observed these Perseids with great diligence in recent years, and retained many interesting notes of their peculiarities. Of 910 meteors belonging to this system, which he saw in the years 1871–79, 526 were accompanied by streaks. These included 158 of the first magnitude, only 15 of which were devoid of streaks; and 243 of the second magnitude, of which 72 were streakless. Amongst the smaller members the proportion was larger. He found the brightest meteors were generally pale-green, others orange, &c.

The luminous streaks, which are known to be the ordinary characteristic of these shooting stars, have acquired a special significance from the fact that by their means the radiant point of the shower is capable of being ascertained with remarkable precision. This important element, to be reliably determined, must rest upon a large number of accurately recorded tracks, which intersect (on being prolonged backwards) at a well-defined position. Many observers have succeeded in finding this from results of more or less value. Mr. R. P. Greg analysed all the positions estimated prior to 1876, and gave the average at R.A. 44°, Dec. 56° N.; and Major Tupman, from a discussion of his own elaborate observations in the Mediterranean during the years 1869–71, derived the point $45\frac{1}{2}° + 56°$, as the centre of 28 sub-radiants. Evidently the two results, being founded on a large number of trustworthy records, and agreeing so closely as they did, showed the true radiant to be situated on the northern limit of *Perseus*, close to the star *Eta* of that constellation; and more recent determinations of a similar nature have fully corroborated that as the chief diverging centre of the August meteors. Many other contemporary showers have been detected in the same region of the heavens, but the shower of Perseids recurs year after year from its accustomed point.

During the last eleven years the writer at Bristol has awaited the annual returns of this shower, and the aggregate results of observations during the interval between the 6th and 12th August, show that 2345 meteors have been recorded, of which 1428 belonged to the display of Perseids, and 917 to other minor streams of the same epoch. In 1869 the radiant was judged to be at *η Persei;* in 1871 at *B. Camelopardi;* and in 1874 at $44° + 58\frac{1}{2}°$. The average position found during the last five years has been at $44° + 57°$; and in the diagram (fig. 2) a number of paths near this radiant are shown. Some of the meteors appear to be slightly erratic in their directions; but this may be explained either by errors of

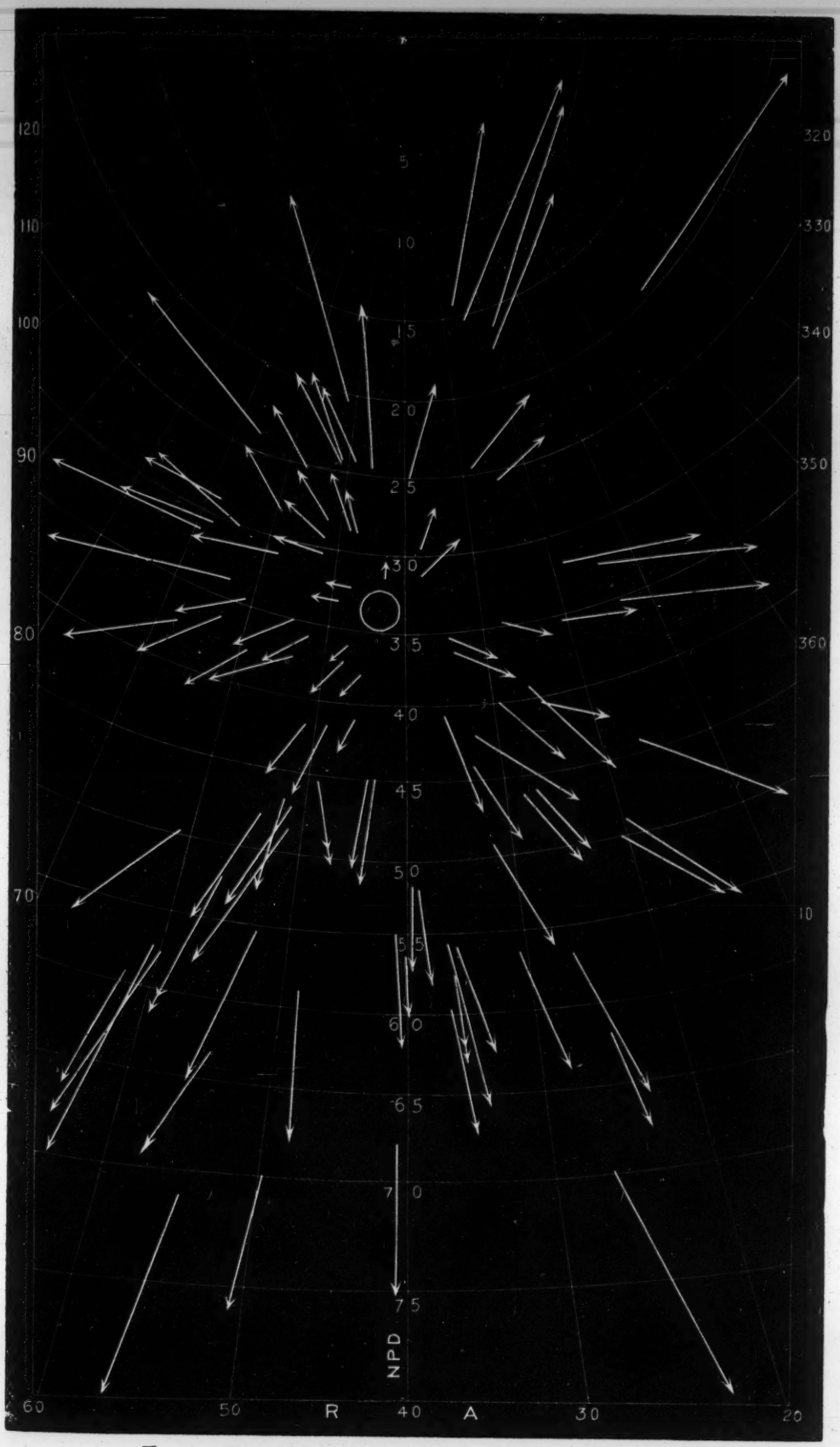

FIG. 2.—Perseids near the Radiant (44°+57°), Aug. 8–12.

observation or by a double or diffused radiant point, which must often occasion non-conformity in the observed flights. In 1878 two points of departure were manifest from a series of precisely fixed courses at 44° + 59° and 42½° + 54°; but in 1879 the weather interrupted observations. The present year, however, afforded an exceptionally favourable opportunity to observers, and the major radiant determined by the writer was at 44° + 56°, with the decided traces of a sub-radiant at 45° + 60°. In 1878 Major Tupman found the shower double at 46° + 57°·6 and 38° + 56°; and in 1880 he strongly corroborated the results obtained at Bristol, though his observations were mainly confined to the night of August 9. At the latter station the radiant apparently advanced amongst the stars of *Perseus*, for while early in the month it was observed at 38° + 56° it had shifted to 49½° + 57½° by the 13th. The same peculiarity was noted in 1877, when the following determinations were made :—

	Radiant.			Radiant.
Aug. 3–7 ...	40° + 56°		Aug. 12 ...	50° + 55°
Aug. 10 ...	43 + 58		Aug. 16 ...	60 + 59

There is a prominent display of meteors from the star-group χ *Persei* at the end of July and beginning of August, and it is possible that these showers may belong to the same system of concentric meteor streams. It is certain that this fact of a progressive radiant requires fuller elucidation, and to this end observers should keep the data obtained each night separate. It may also be suggested that the radiant point should be ascertained during each hour of observation, and then when the series are compared, any displacement must immediately become obvious, and its extent and character well defined by the observations. The meteors from *Perseus* are so numerous, and the place of divergence so readily denoted by their enduring streaks, that there will be no difficulty in an investigation of this kind. The last two years' observations have shown how exactly the radiant may be found by carefully-conducted researches, and how closely the positions derived by different observers will agree on being compared together :—

Observer.	1879, August. Chief Radiant.	1880, August. Chief Radiant.
G. L. Tupman . . .	45° + 56° ...	44° + 56°
H. Corder	45 + 57 ...	45 + 58
E. F. Sawyer . . .	44½ + 57 ...	44¾ + 56¼
W. F. Denning . . .	46 + 58 ...	44 + 56

From these values a mean of 44°·8 + 56°·8 is derived, which

is probably very near the truth. There is a secondary shower higher in declination (at about $44\frac{1}{2}° + 60°$), but this is merely a branch of the same stream, for the meteors exhibit the same specialities of appearance as those common to the major shower. An apparent diffuseness of the radiant point is often brought about by imperfectly registered tracks, and by allotting the meteors of bordering showers to the radiant of the Perseids, when in fact they belong to evidently distinct families.

A few years ago the writer undertook the investigation of these co-Perseid showers from the large mass of shooting stars which had been registered at this epoch at foreign observatories, and are contained in the published catalogues of Heis, Schiaparelli (1872), Weiss, and Konkoly. These include many thousands of paths observed during the period from Aug. 6th to 12th; and such of these as were obviously directed from radiant points situated eastwards of *Perseus*, were projected on the star-maps prepared by Prof. Herschel for the purposes of the Luminous Meteor Committee of the British Association. In all 762 meteors were thus utilized, and they gave distinct evidence of the positions of a number of active streams in *Auriga* and *Camelopardus*, some of which were previously observed by Heis, and many of them have been confirmed by the writer during the last five years. The following list embraces the chief radiants thus deduced :—

Meteor Showers east of Perseus, August 6–12.

No.	Radiant. α	Radiant. δ	No. of Meteors.	No.	Radiant. α	Radiant. δ	No. of Meteors.
1	70°	+ 64°	74	10	134°	+ 77°	30
2	61	+ 39	59	11	74	+ 33	28
3	96	+ 71	87	12	104	+ 34	13
4	61	+ 48	59	13	99	+ 46	17
5	51	+ 74	62	14	45	+ 33	18
6	78	+ 56	59	15	76	+ 74	20
7	76	+ 45	43	16	52	+ 20	14
8	50	+ 47	42	17	87	+ 34	14
9	92	+ 57	42	18	87	+ 15	8

The relative positions of these showers are depicted in the diagram (fig. 3) where the more prominent displays of the group are represented by deeper circles than the minor. Some of the latter cannot yet be regarded as certainly established, inasmuch as they rest on slender materials.

Heis devoted much attention to the meteors of the August period during more than forty years (1833–75), and in his extensive 'results,' published in 1877, gives the following as the chief radiant points for August 9–11 :—

Symbol.	Radiant. α	δ	No. of Meteors.	Symbol.	Radiant. α	δ	No. of Meteors.
A_{11}	45°	+ 52°	233	Cr_{11}	273°	+ 56°	93
B_4	330	+ 55	164	St_{12}	40	+ 45	118
B_5	292	+ 70	135	St_{15}	56	+ 70	105
Cr_5	12	+ 32	93	St_{17}	27	+ 21	70
Cr_6	355	+ 81	103	St_{18}	25	+ 58	282
Cr_8	11	+ 60	192	St_{19}	295	+ 44	110
Cr_9	73	+ 63	125	St_{20}	51	+ 75	133

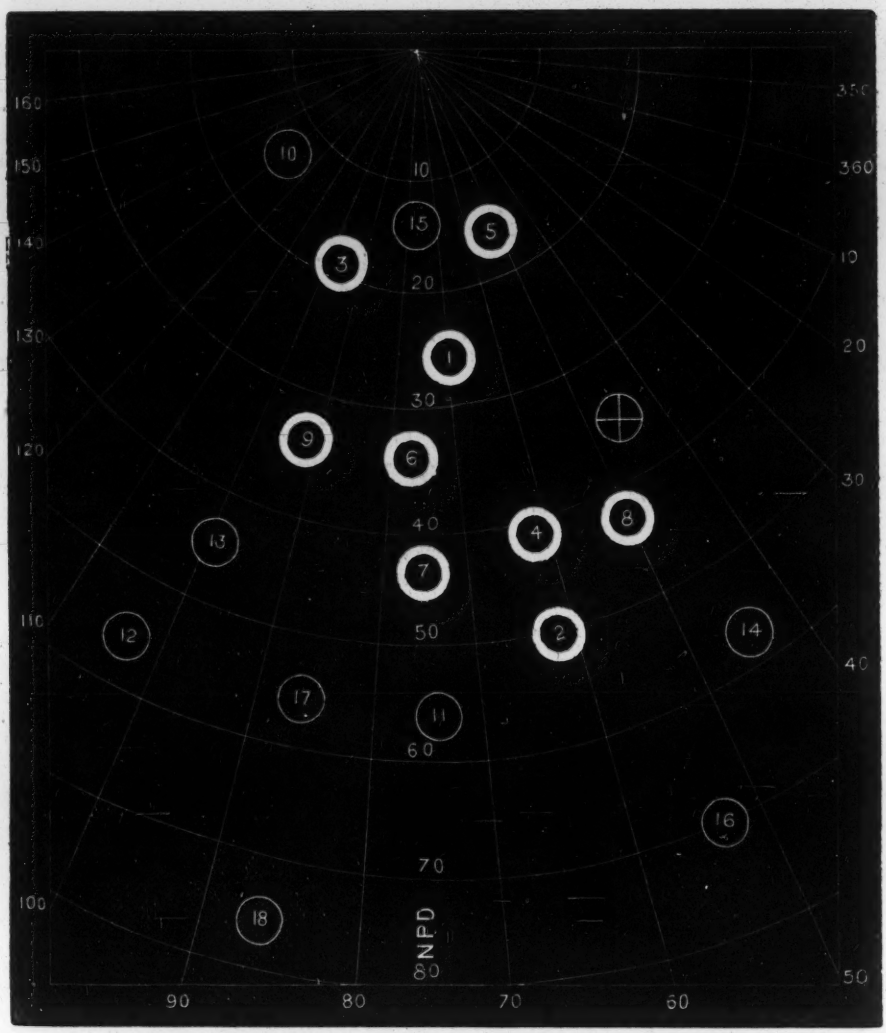

FIG. 3.—Radiant Points east of the Perseids, Aug. 6–12.

Major Showers. Minor Showers. Perseids.

But in addition to these, there are a large number of radiants scattered over the sky, especially in the eastern

quadrant. One of the most notable of these proceeds from the eastern extremity of *Aries* (44° + 25°), and supplies some bright meteors in the morning hours; but the most conspicuous shower discovered east of *Perseus* at this epoch lies in *Camelopardus*, and in the diagram (fig. 4), a number of its meteors falling amongst the stars of *Ursa Major*, are reproduced from the catalogues of foreign observers. This shower, however, escaped the detection of Heis and others, who had been engaged in similar investigations, though it appears to be of more importance than several radiants in its vicinity which have been independently determined by several observers. At the end of July 1878, the writer noted a few

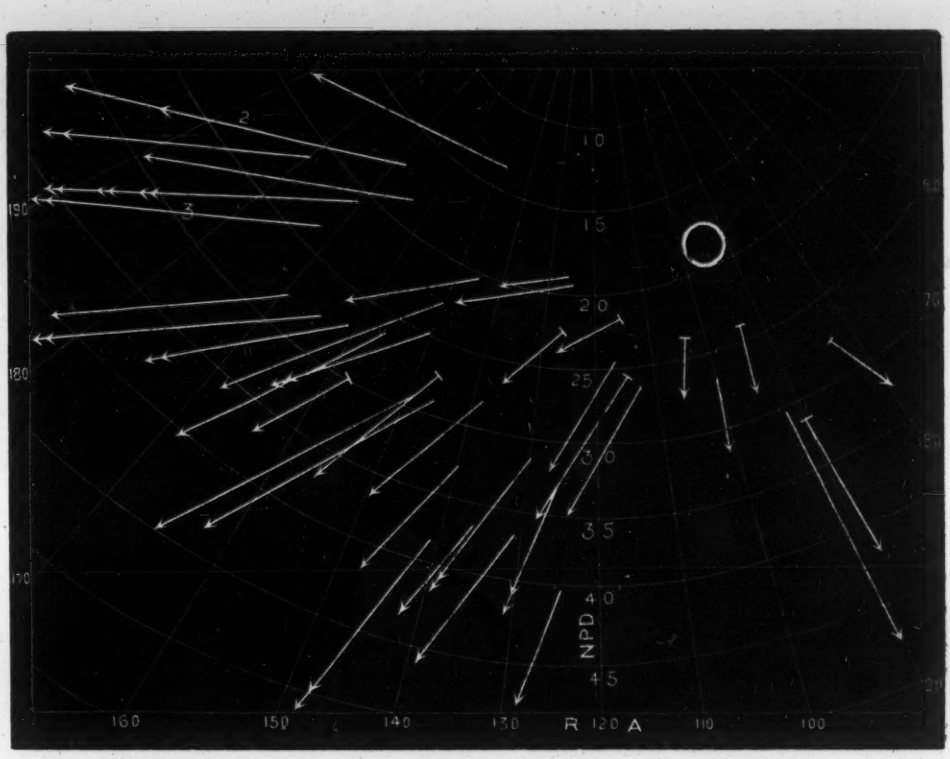

FIG. 4.—Shower from *Camelopardus* (96°+71°), Aug. 6-12.

brilliant, slow meteors, from a point at 96° + 72°, and this may have been an early evidence of the radiant which is placed in a region bare of large stars between *Telescopium* and *Polaris*. It is just north of the triangle of faint stars (*l. p. q. Camelopardi* of Bode), east of a line drawn from β *Aurigæ* to *Polaris*, and will, no doubt, be frequently re-observed in future years, though the shower of Perseids usually monopolizes attention at the epoch of its annual returns.

There is a shower near η *Persei* (No. 2), well defined, on Aug. 6–12, Aug. 21–23, and Sept. 6–15. At the latter epoch it furnishes some fine meteors and constitutes a prominent dis-

play. The diagram (fig. 5) gives the positions of eighty-six paths conforming to this radiant, observed at Bristol, and at several foreign stations in September.

The ordinary designation of Perseids for the special meteor shower of August 10, is always understood in its individual application, though it must not be supposed that this is the only shower of Perseids visible in that month. The fact is, there are many separate showers directed from that constellation early and late in August, so that we require some distinguishing titles or symbols to conveniently particularize either of them which it may be necessary to refer to. The method now adopted of naming the chief periodical showers by the constellations in which their radiant points are situated, is very appropriate; and such displays as the Orionids, Leonids, and Geminids, have become so well known by their titles, that it would be unwise and inconsistent to attempt reform. But with regard to the minor systems, which are becoming very numerous, and require an equally ready mode of expression, there is a great difficulty in avoiding complications.

There are certainly five nearly simultaneous showers of Perseids early in August; and in every month of the year, except May and June, meteors continue to fall from that constellation. If the present mode is adopted of styling them Perseids I, Perseids II, and so on progressively, a good deal of confusion must eventually arise as new systems are discovered; and this classification by Roman numbers, however appropriate it may be in some of its other applications, will have to give way to a more distinguishing means of reference. The name at present only gives indication of the constellation from which the meteors emanate, without regard to the date or approximate place of the radiant, and it seems to me that the difficulty may be obviated by including the nearest fixed star and the epoch with that name. To render the proposal clear let us take the different streams proceeding from the undermentioned points in *Perseus* in August:—44°+56°, 32°+53°, 61°+36°, 61°+48°, 46°+47°, which may be thus termed:—

η Perseids (Aug. 10).
χ Perseids (Aug. 1–3).
ϵ Perseids (Aug.).
μ Perseids (Aug.).
α Perseids (Aug.).

This is apparently a preferable method to that of Perseids I, II, III, IV, and V, which must occasion endless trouble in references to find what special stream is meant. Moreover the numbers seem only in fair application when affixed progressively to the

successive showers of the year, for it would be hardly consistent to call a radiant visible in *Perseus* early in January by the designation of, say, 'Perseids XXXVIII.' Yet this is what we are

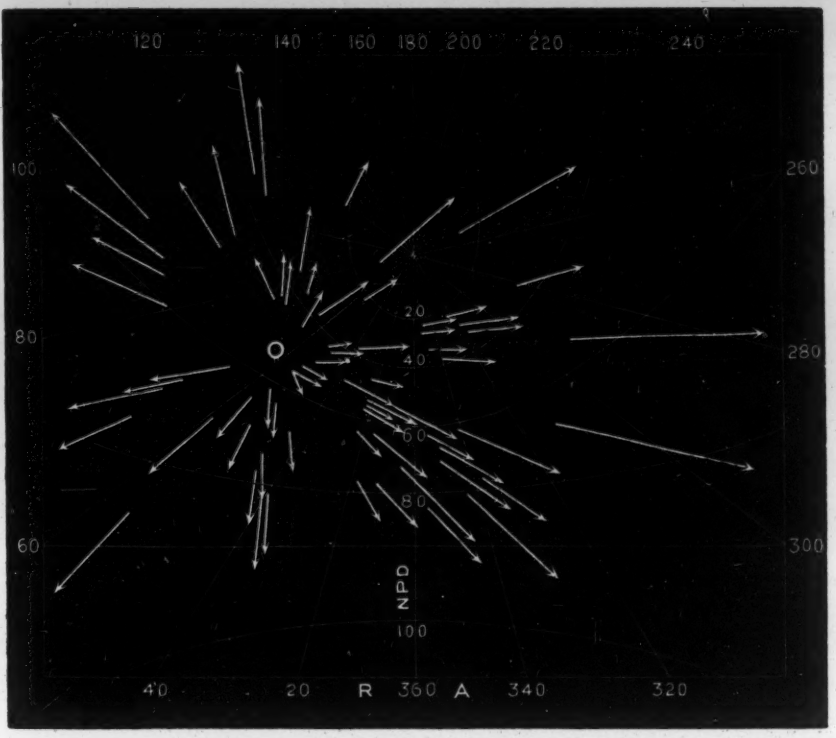

FIG. 5.—Shower of ε Perseids (61° + 36°) max. Sept. 6–7.

drifting to, unless a fresh system is introduced to accommodate the rapidly increasing number of meteor streams.

A LARGE CRATER.

By Prof. JOHN MILNE, F.G.S., Japan.

THE crater I wish to describe is called Asosan. It is situated in Kiushiu, the southernmost large island of the Japanese empire. The width of this crater is about fifteen miles, and in the bottom of it there are living, and living for aught I know in peace and plenty, about 20,000 people.

The way in which I came to find this crater was this: for the last four years I have been spending my spare time in travelling about Japan geologizing and visiting volcanoes. At the end of the summer of 1878, the only island of Japan which remained for me to see was Kiushiu, and a part of this I made up my mind to travel over during the coming Christmas holidays. After making application for extra leave, which was very kindly granted to me, I left Yokohama *en route* for Nagasaki, which for foreigners is the chief town in Kiushiu, on the afternoon of the 17th of December; the greater portion of this journey, which can all of it be performed in a comfortable steamer, is down what is called the Inland Sea. This journey is a trip which is made by everyone who visits Japan, and rather than being a journey down a sea, as its name implies, it is more like a journey along a river or a lake, which in places is so thickly studded with little islands, that at every moment they seem to come within a stone's throw. After a day's rest at Nagasaki, where I was joined by Mr. A. Wooley of the British Legation, I took a small steamer bound from Kumamoto to the capital of Hizen, one of the chief seats of the fighting during the last rebellion. At this point I may say that the luxuries of travelling were ended; and not knowing that there was anything particularly interesting before me, it was not with feelings of pleasure that I left the steamer and took to muddy roads and Japanese hotels. Foreigners who only come to Japan for a week and travel along a well-frequented road, or in the neighbourhood of an open port where the habits of the strangers from afar are more or less

understood, write descriptions of the empire of Japan sufficient to induce the whole world to come and settle in it. If, however, these gentlemen had been compelled to travel for say two consecutive months upon Japanese food and in districts somewhat remote from the great capitals, I think, if they ever lived to tell the story, that they would write a different account from those which we usually read,—when it becomes an absolute necessity to walk over mountain-passes which are more like flights of steps than ordinary roads, to sleep on hard mats, and to subsist on vegetable diet, the chief portion of which consists of rice and a radish called 'daikon,'—the hardships of travelling in Japan will be fully recognized. Occasionally a foreigner will endeavour to travel as a native; but usually, after finding that his health has suffered, you will discover him to have fallen back upon the usual plan of travelling, the essential part of which is to have a native servant and a pack-horse to carry some provisions; and under these circumstances it is but seldom that you can find a foreigner who is able or who cares to continue his exploration beyond the period of one month. At the end of that time, having lost ten per cent of his original weight, and longing for the flesh-pots of the open ports, he beats a quick retreat from the rugged hills and brawling streams, the enjoyment of which is hemmed in by so many difficulties.

From Kumamoto, where, in the new town, the ruined castle, and groups of troops, I saw indications of the recent war, I travelled directly eastward along a road which upon the native maps appears to lead from one side of the island to the other. Straight before us we could see Asosan, the mountain to which we were going, giving off heavy clouds of steam; between us and this there was a long range of rugged hills parallel with the coast which we had just left behind us; these looked reddish and bare, but when we came actually upon them, I found that their colour was due to a covering of brown grass, and not to earth and stones, as I had previously supposed. The road on which we travelled was, for a Japanese road, very wide; on each side of it there were two lines of trees, the lines nearest to the road were wax-trees, whilst those behind them were cryptomerias. As the wax-trees had lost their leaves, they looked very bare and ragged, but in summer time, when they are in full foliage, they must form an avenue which I think would far surpass anything I ever saw in an English park. Roads bounded with lines of tall trees are a feature in Japan, and some of these which continue for twenty or thirty miles in almost unbroken lines, form sights which when once seen will always be remembered.

After eleven and a half miles up this road, we reached the

village of Odzu, where we took up quarters for the night. Early next morning we started out upon frozen roads to climb the hills which were before us. The ascent was gentle. Right and left were broad stretches of uncultivated grassy ground. Away upon our left we could see a high mountain called Kuratake, which, from its general shape, and a rugged-looking hollow which had been breached upon the side towards which we were looking, seemed to represent the remains of an old volcano. Looking back, we could see the plain across which we had come on the previous afternoon; at the edge of it where it reached down to the sea, we could just make out the position of Kumamoto; whilst beyond that, at the other side of the bay on which Kumamoto is situated, there rises a rugged mass of mountains, the highest peak of which was the volcano Unsen. This volcano is the one which, amongst all Japanese volcanoes, has probably been the most destructive.

FIG. 1.—Ring Wall of Asosan as seen from Futaiyai-no-toge.

1. Dobindake. 2. Asosan (smoking). 3. Nekodake. 4. The Ring Wall. 5. Yudake. 6. The Crater Plain, with villages, clumps of trees, and rice-fields.

In 1793, during an eruption which extended over many days, a large portion of it literally blew up. The earthquakes that accompanied this outburst—the rushing in of the sea, and the falling boulders and fiery rain of red-hot cinders—laid waste the surrounding country, and took away the lives of fifty thousand of its inhabitants. The scenes which occurred during this eruption were too horrible for description, and, as a Japanese historian remarks, the terror and the ruin were unparalleled.

Turning round, and continuing the ascent, after a little more climbing we reached the top of the ridge called Futaiyai-no-toge; and here, before us, was a sight which was as striking as it was unexpected (fig. 1), because the ascent from the sea up to this point had been so gentle, being indeed only about 1750 feet. We had naturally expected that on reaching the

summit we should have before us a descent equally easy, but instead of that we found ourselves standing on the edge of what was nothing more or less than a deep pit, which, so far as we could see, was nearly circular. The greater portion of the sides of this pit were perpendicular cliffs of rocks, which here and there, near their upper parts, showed the irregular, broken stratification, so characteristic of the sides of many craters. In places at the foot of these cliffs a sloping talus had been formed; whilst in other places (which, I may remark, were few in number) the cliff-like forms had been so far denuded that the sides of the pit formed irregular, but exceedingly steep, slopes. Looking at this pit from the commanding position in which we stood, I estimated its width at seven miles; and it was not until we descended, and tried to walk across, and found how little was the progress which we made, that we recognized how far we had underrated its true dimensions. In the middle of the pit, and running up far above its sides, there is a large, irregular block of mountains, the central peak of which is always giving off large clouds of steam. This peak was Mount Aso, the goal of our journey. From the rim upon which we stood, by a zig-zag pathway, we quickly made the descent to the crater plain below us. The depth at this point was about 600 feet.

At the foot of these mountains the priests have their permanent rendezvous, and on the summit small temples and shrines, where during fixed seasons they reside, and receive the crowds of pilgrims to the deities of the mountain. The number of pilgrims who ascend the famous Fujiyama every year must be many thousands, and the fees the priests derive thereby, from the toll-gates on the upward paths which they have established, are very numerous, and must form a considerable revenue. If you visit some of these mountains at any other time than the appointed season, you may be refused permission to ascend. I myself was refused in this way at Iwakisan, one of the most beautiful volcanoes in northern Nipon. On another mountain, Chokaisan, I was subjected to a most curious treatment. I commenced ascending this mountain, and after scrambling over blocks of lava, and up long fields of snow, I reached the top, faint and weary, at half-past one o'clock p.m. My first impulse was to eat and drink, but in this I was prevented by four priests, who insisted that before satisfying either my hunger or my thirst I ought to pay my devotions at a small shrine which they had built. Being too tired and feeble to resist, I allowed them to lead me into the shrine, where I dropped on my knees before the idol between two priests, who, after putting on their robes of office, commenced to invoke the deity, and beat small drums. After this, they opened a small door in front of

me, and showed me my reflection in a metal looking-glass, where I suppose I was expected to see the lines which sin had graven on my face. Next, one of them handed me a large, clean, metal bowl. Instinct told me that an opportunity was coming to satisfy my thirst; so I took it reverentially in my two hands, and the priest immediately filled the bowl up with Japanese wine (*saki*), which I learnt afterwards had been dedicated to the gods. Never did nectar taste so good. After the first half pint the priest invited me to more wine, and, feeling faint, the offer was readily accepted. Again the offer came, but this was too much; modesty overcame me, and putting down twenty cents as an offering to the gods, I withdrew to my sandwiches. This was a Japanese sacrament, and I must say that I found it very good. The question now comes, What does all this mountain-worship mean? The reply to it I think we find in Buckle, who shows us how the imagination of a people has been excited by all great natural phenomena, especially those like earthquakes and volcanoes. The terror which a volcanic eruption has caused, like that at Unsen, when fifty thousand people were slaughtered almost in one night, we have historical evidence to show has been the cause of many superstitions. The phenomena were so terrible, so unexpected, and at the same time so inexplicable, that to account for them superhuman agencies were invoked and gods created. In Italy and Spain it would seem that it is to these seismic and volcanic agencies that we are in a great measure to attribute not only the superstitious character of the people, but also their poetry and arts. In Japan, however, the most prominent result of these terrible catastrophes appears to have been the cultivation of superstition. Not only has the religion probably been to a great extent an outcome of the phenomena of nature; but if we examine into their literature, and observe their sentimental reverence for antiquity, and the *conventionalities* in their art, we shall see that much of what is so peculiar in the national character of the Japanese may probably find an explanation by looking in a similar direction. This subject, however, is too large to dwell upon here.

From the foot of the crater to Bojo I calculated the distance to be about five miles, and as this point was about half way across this portion of the pit the total width would here be about ten miles. From a map of the crater, which our host, who kept a small shop in Bojo, made for me, the diameter in some directions must be fourteen or fifteen miles. This I confirmed by sketching in the position of the crater upon a map prepared by the government. Looking on the map, inside the space I marked out as being the boundaries of the crater, I counted about eighty villages. Fifty of the villages, our host

said, were a moderate size. If these contained say on an average three hundred people, then living in the crater there must be from fifteen to twenty thousand people.

Airy, in his *Popular Astronomy*, tells a story of an early philosopher, who, when writing a paper for the Royal Society intending to prove the truth of the Copernican theory, commenced for some reason or other with the assumption, 'Now we all know that hell is in the centre of the earth.' If this assumption is true—and it emanated from a member of a very learned body—the twenty thousand people I have referred to are perhaps unwittingly living upon the lid of that establishment.

The following account, which was given to me, of the last eruption of Asosan, might, in the mind of that early philosopher, have helped to strengthen his hypothesis:—'During the winter of 1873 sounds were heard, and white and black smoke was observed proceeding from the top of Asosan. On the 27th February in the following year, whilst the wind was blowing from the south, the ground began to quake, and ashes were thown out. What the thickness of the beds of ashes in the rice-fields was we cannot tell, but near to us they obtained a thickness of one inch. The ashes covered everything, and the leaves of the pine-trees and the wheat were turned quite red. At six o'clock in the morning of the 13th the ground again began to shake, and noises were heard on an average a hundred times an hour. On the 14th, at six o'clock, there were two or three very heavy shakes, and on the 23rd these became still more violent. These shakings were so strong that neither old nor young could sleep. They continued on the 24th, but on this day the eruption ceased. The material which was thrown out was of a grey colour, but afterwards it became red. The greatest quantity of ashes fell at Kurogawa-gumi and Higashi-kurogawa. At the commencement of the eruption, which was on the 1st of December, 1873, the volcano threw out stones one and two feet in diameter; and four men, who were working at some sulphur deposits on the top of the mountain, were immediately killed. Many hot springs burst out, and so much sulphurous matter was thrown into the river Shirokawo, which flows from this crater to Kumanoto, that all the fish were poisoned. Even up till the 3rd of March, 1874, shocks were felt, and material was thrown out which covered the ground for a distance of eighteen miles. During the day it was at times as dark as night. Previously, in 1806, there had been another serious eruption. The fame of this mountain spread even to China, and in a Chinese book I found the following:—

'Smoke rises up to the sky from mount Aso in Nipon. People say that in this mountain there is a precious stone of

a blue colour and shaped like an egg, which shines at night. They worship this, and call it Antikokusan. The shining smoke on the top of this mountain has three colours, which can be seen from a distance of three miles; these three colours are blue, yellow, and red.'

On the morning after reaching Bojo we started off to ascend the central peak of Asosan. After a climb of about 200 feet we turned round to look at the crater which we were leaving. At our feet was a cultivated plain dotted over with clumps of trees and villages, beyond which there was a line of fir-trees and Cryptomeria. These formed a belt round the foot of the amphitheatre of perpendicular cliffs which intercepted any further view. Before us, but on the left, there was a rugged peak called Nekodake, a portion of which looked very like a ruined crater. To the right and to the left of us was a wide expanse of sloping ground covered with brown grass. When we were 400 feet above Bojo we came to patches of snow. As we neared the top we crossed one or two old lava streams and beds of ashes. At the height of about 2000 feet above our starting-point, or about 3600 feet above the sea, we were on a level with the upper crater of Asosan, a huge black pit which was giving off vast clouds of steam. All the rocks which I saw up to this point were andesites, similar to those which form the ring-wall of the outer crater. Here we found one or two men who were engaged in collecting sulphur. Upon our right there was a rounded hill called Dobindake, which rose almost 500 feet above the level of the crater. The extreme height, therefore, of Asosan above the sea-level is perhaps a little over 5000 feet. From this position we had a good view of the big crater which surrounded us, as the slope on its outside is generally so gentle that it looked like a huge pit with perpendicular sides which had been dug out of the top part of a piece of ground in shape like an inverted saucer. On the northern side the cliffs which bound this pit are almost everywhere perpendicular; but on the south side, which was the side towards which we descended, they were more worn away to form rugged hills. The cliff-like character, with its horizontally-stratified structure, could, however, be in many places distinctly traced. That night, foot-sore and tired, we reached a village called Kurokawa. The only lodgings we could find were in a school-house, where, after a supper of biscuits, we shivered all night, lying upon the boards with our top-coats to cover us, our arms for pillows, and the thermometer somewhere below zero.

Next day we left the crater, passing through a breach in its north-west side. It is through this opening that the Shirokawa flows, the river which with its tributaries drains the crater plain.

Six days later, after walking many miles along roads which were often nearly a foot deep in mud, subsisting mostly on a poor vegetable diet, sleeping continually in our top-coats, caps, and all the clothes we could command, and experiencing snow, and rain, and hail, we were once more back enjoying the luxuries of Nagasaki.

Now, how does the crater of Asosan compare with other craters in the world? Amongst those which are active it appears to be the largest which has hitherto been discovered, and even if we include those which are extinct, it appears to take the foremost place.

Scope, in his valuable work on Volcanoes, amongst other remarkable craters, speaks of the following:—

In St. Helena there is 'a trachytic volcano encircled by a broken ring of basalt, the area of which measures eight miles by four.'

In the Mauritius there is a crater the shortest diameter of which is thirteen miles.

In St. Jago (Cape de Verde Isles) there is a similar crater.

The Cirque of Teneriffe is eight miles by six.

Pantellaria (near Sicily) has traces of a crater twelve miles in diameter. The rock is trachytic.

Bolsena (an oval lake basin) twelve miles in diameter.

Papandayang (Java), here there is a hollow fifteen miles by six, supposed to have been formed by the blowing off of the entire summit of a mountain by long-continued explosions.

Bromo (in Java) is a crater four or five miles in diameter, with perpendicular sides a thousand feet in height.

Another point of interest about a mountain like Asosan, and one which would form food for the speculation of almost every visitor, is the question as to how such a crater has been formed.

If I read Mr. Scrope aright, I must imagine that over this crater there was once a volcano, the upper portion of which, by a series of violent explosions, has been blown to atoms. In many cases the origin of craters in a manner like this is no doubt true, and this I may say, not because I should myself have imagined it, but because competent witnesses have seen the operation actually performed. In certain cases, however, and certainly in the case of a crater like that which we see at Asosan, I should be inclined to modify the suggestion of such paroxysmal causes and adopt something more gentle, and which to me seems more in accordance with the facts.

If from the heights and distances which I have given we make a drawing of Asosan, it will be found that the average slopes in the outside of the large crater must be about six degrees, and if we were to continue this slope upwards, we obtain a representation of the portion which, if it ever existed, has been

blown away. If such an occurrence has ever taken place, I find by calculation that we have to account for thirty-five cubic miles of material which represented the cone, and about seventeen cubic miles representing the crater, or in all fifty-two cubic miles of material which have disappeared. If the action was paroxysmal, surely some of this material ought to be found in blocks and boulders, distributed round the outside of the big crater. Although I crossed the outside mountain in two paths, I must say that I failed to meet with such material, in fact I do not remember seeing even a single boulder, all was smooth.

If in spite of this we still hold on to the idea of paroxysmal actions, the only refuge which we have seems to be that the whole of this vast quantity of material was suddenly dissipated as dust. A conclusion of this sort seems to me improbable; and instead of regarding this crater as the basal wreck of some large mountain, I should be inclined to look upon it as being now as it ever was, the upper crater of an old volcano, inside which in more recent times a cone has grown. Although at the commencement of the mountain the action may have been cataclysmic in its nature, subsequently, however, I should think that it grew up higher, partly by the accumulation of ashes, but now perhaps by the boiling over of a highly liquid trachytic lava. That this latter action has taken place seems to be testified by the roughly stratified appearances which are exhibited in the ring walls; the growth has, in fact, been probably something like the growth of Mauna Loa in the Sandwich Islands, or a geyser tube in Iceland. I may also add, that were we to suppose the upper portion of a mountain like that which must have existed if we complete in our imagination the truncated remains which bound large craters such as Asosan to have been blown away, we are, I think, assuming that the later eruptions of these mountains were more powerful than the first, whereas, I think, experience teaches us that the reverse is generally the case, as the action of a volcano continues by the quantity of material it piles upon itself. The hydrostatic pressure of its new column of lava, the increase in size of the cavity produced by evisceration in which we may suppose the actuating steam to be confined, are causes which will all help to make succeeding outbursts vigorous. No doubt examples might be quoted to show the reverse of what is here suggested, but I think that many more examples might be collected to show its truth; and certainly if we could regard volcanic energy as a whole through all past times, the enfeeblement in volcanic energy which has taken place would be fully recognized.

Amongst the large craters which I have mentioned, and

these are the largest which are recorded by Scrope, it would seem that Asosan, considering its size and its activity, is without a rival. If we go further, leave the earth and compare Asosan with craters which we find upon our satellite the Moon, although it cannot stand before a pit like that exhibited by Copernicus, which is said to have a diameter of fifty-six miles, it nevertheless may be regarded as an example of healthy competition.

As an active volcano, however, it still holds its place; and if America boasts of the largest waterfall, and India of the highest mountains, in one of the most prominent classes of natural phenomena Japan, also, will be able to take an equally prominent position. Further explorations may perhaps lead to the discovery of craters which will excel Asosan; but so far as present knowledge is concerned, amongst the active craters in the world, as yet Asosan appears to be pre-eminent.

And now not only may the Japanese boast of possessing one of the most beautiful of volcanoes, which mountain is the far-famed Fuji, but they may boast of one of the most remarkable of craters.

REVIEWS.

FRESH-WATER RHIZOPODS.*

WE often enough hear of the great effects produced in the world by the smallest organisms; and one of these seems to be their giving origin to big books. Ehrenberg's *Infusionstheichen* and *Mikrogeologie* are large folios, and many authors have devoted stout quarto volumes to the publication of their researches upon Infusoria, Foraminifera, and Radiolaria. To this number we have to add Prof. Leidy, who has just brought out a magnificent volume upon the fresh-water Rhizopods of North America. This work is a posthumous publication of the defunct Geological Survey of the Territories, which, under the able superintendence of Dr. F. V. Hayden, did so much admirable work in various departments of natural history; and we are glad to see that, notwithstanding the change that has taken place in the arrangements of the United States Surveys, the investigations inaugurated and carried on by Dr. Hayden and his assistants are not likely to be lost to the world.

Prof. Leidy has devoted several years to the investigations of which the results are published in the work now before us. Besides collecting assiduously in the vicinity of Philadelphia and other parts of Pennsylvania, in New Jersey, Connecticut, Rhode Island, and Nova Scotia, on the Atlantic side of the continent, he has devoted two seasons to an examination of the forms inhabiting some of the far distant regions of the west—especially the Bridger Valley, in the south-west of Wyoming, and the Uinta Mountains, in the same region. In the last-mentioned locality he pursued his researches up to an elevation of 10,000 feet.

Of course it is unnecessary to say that such investigations do not by any means make us acquainted with all the forms of the groups here treated of which may be found within the vast territories of the United States, nor does Prof. Leidy claim to have even approximately exhausted his subject.

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* *Report of the United States Geological Survey of the Territories. Vol. XII. Fresh-water Rhizopods of North America.* By Joseph Leidy, M.D. 4to. Washington: Government Printing Office, 1879.

His object, and that of Dr. Hayden, in the production of the work, was to show observers in the States what a wealth of interesting objects awaited their investigation, and to furnish a trustworthy guide-book which would enable them to know what had already been done.

At the same time, we think that the author has indicated (not only here but in scattered papers published during the progress of his researches) that these lowly organisms are much more generally distributed than was formerly supposed. He says: 'Freshwater Rhizopods are to be found almost everywhere in positions kept continuously damp or wet, and not too much shaded. They are especially frequent and abundant in comparatively quiet waters; clear, and neither too cold, not too much heated by the sun . . . . . They are also frequent in wet bogs and savannas, among mosses, in springy places, on dripping rocks, the vicinity of waterfalls, springs and fountains, and in marshes, wherever the ground is sufficiently damp or moist to promote the growth of algæ. They are also to be found in damp, shaded places, among algæ, liverworts, and mosses, about the roots of sedges, rushes, and grasses, or those of shrubs and trees growing in or at the borders of bogs and ponds, or along ditches and sluggish water-courses. They are likewise to be found with algæ in damp, shaded positions in the depressions and fissures of rocks, in the mouths of caves, among decaying logs, among mosses and lichens on the bark of growing trees, and even in the crevices of walls and pavements about old dwellings, and in cities.'* And to encourage the student to work upon this abundant and almost ubiquitous material, he adds that it is a mistake to suppose that a very elaborate microscope is necessary for its examination, such an instrument as may be procured for about 10*l.* being generally sufficient for every purpose. We may add that he gives full directions for collecting the animals in various localities.

Dr. Leidy regards the Rhizopoda (which he accepts in the old sense of the term) as including five orders, namely, Protoplasta, Heliozoa, Radiolaria, Foraminifera, and Monera. Of the last he candidly admits that he knows no freshwater form, unless *Vampyrella* (here referred to the Heliozoa), which Häckel places among his Monera, really belongs to that group. The Radiolaria are marine; of the Foraminifera our author admits one freshwater type, *Gromia;* and the rest of the forms described by him belong to his orders Protoplasta and Heliozoa. The Protoplasta includes the whole of the Amœboid forms, whether naked or shelled (*Protoplasta lobosa*), as well as the Euglyphoid types (*P. filosa*); to the Heliozoa are referred *Actinophrys* and *Actinosphærium* with the allied forms which have been made the types of distinct genera by various authors, and also, as already stated, the genus *Vampyrella* of Cienkowski. The only representative of the genus *Gromia*, described as a new species (*Gromia terricola*), was found with Rotifers and other organisms among moist moss in the crevices of pavement in a yard in Philadelphia.

It is impossible to estimate too highly the care and labour that Prof. Leidy has bestowed upon the preparation of this splendid work. All the forms discovered by him are described in the most careful manner, as regards both their form and structure, and their habits; and the opinions of authors

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* P. 8. Lists of forms obtained together will be found at pp. 289–293.

on this side of the Atlantic are cited and discussed, where necessary, in great detail. Taken in conjunction with the beautiful series of forty-eight coloured plates with which the descriptions are illustrated; this portion of the work, as a means of distinguishing the organisms, and as a 'recreation of the eye,' as old Knorr has it, leaves little to be desired. But we cannot help thinking that the author would have done better, and have given his work a far higher value, had he taken a rather more philosophical view of what is wanted in the shape of genera and species in the classification of these lowly organisms. The multiplication of generic names especially is a continual stumbling-block to everyone but the mere specialist; and when we examine the beautiful figures here given and compare them with the observations and figures of Dr. Wallich (*Ann. Mag. Nat. Hist.* 1864), one is driven perforce to accept the views of the latter distinguished observer, and to hold that, for the purposes of science, the establishment of species and genera upon slight variations in the form and structure of little cases like those of the *Difflugiæ* and *Euglyphæ*, is worse than useless. Nay, Prof. Leidy himself evidently holds a very similar opinion, for he cites the authority of such observers as Carpenter, Williamson, Wallich, Brady, Parker, and Jones to show 'that the members of the class are infinitely variable, and that indeed no absolute distinctions of species and genera exist, such as appear more definitely to characterize the higher forms of animal life.' He adds: 'My own investigations rather confirm this view, and, under the circumstances, we can hardly regard the more conspicuous and prevailing forms as so many nominal species, in likeness with the species of higher organic forms, more or less intimately related, and by intermediate forms, or varieties, merging into one another' (p. 6). This seems very nearly to express the state of the case; but because there are no well-marked or easily distinguishable groups, it by no means follows that it is of no consequence how many groups we adopt.

In these remarks we have no wish to detract from the value of Prof. Leidy's magnificent work, which is not only a splendid monument of much labour carefully and intelligently performed, but also a most important and indispensable book for the investigator of the lowest forms of animals. We congratulate him heartily on its completion, and on the exceedingly satisfactory manner in which it has been produced.

METEOROLOGY.*

There has lately been an addition to the Literature of Meteorology in the shape of two pamphlets, each of which merits some notice. The first issued officially by the Meteorological Office is entitiled *Aids to the Study and Forecast of Weather;* and the second by E. J. Lowe, F.R.S., is called *The Coming Drought, or the Cycle of the Seasons, with a Chronological History of all the*

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* *Aids to the Study and Forecast of Weather.* By W. Clement Ley, M.A. 8vo. London: Bemrose & Sons. 1880.

The Coming Drought, or the Cycle of the Seasons. By E. J. Lowe, F.R.S. 8vo. London: Bemrose & Sons. 1880.

Droughts and Frosts as yet found recorded from A.D. 134 *to the present Time*, a title that irresistibly reminds the reader of the black-letter ballads of some centuries ago. Both books have one object, the very important one of showing how in our very variable climate the weather may be foretold; but the scope, the matter, and the investigations are very different in the two cases. In Mr. Lowe's pamphlet we have information extending over centuries, observations collected from all quarters of the globe, the results generalized, and a large margin given; while Mr. Ley's work contains all the minutiæ of the science, the small meteorological phenomena of every-day life being there noted and explained. Neither work pretends to greater distinction than that of being a short sketch of the subjects of which it treats; and in the case of Mr. Lowe's book, it is avowedly an introduction to a more important work which is now in course of preparation.

The '*Aids*' is divided into three distinct parts. It deals first with the most important non-instrumental observations to which attention should be given by the student of the weather; secondly, with the relations which exist between the winds and the distribution of barometric pressure; and thirdly, with the conditions of weather which attend and characterize atmospheric disturbances.

With the exception of a few words as to 'backing' and 'veering,' wind observations are shortly dismissed, and the author passes on to the subject of Clouds. To this subject he has evidently given his closest attention, and it is evident from his remarks that by closely watching the varieties and movements of clouds, good guesses as to changes of weather can be made even for two or three days in advance. Other weather signs are then discussed by the author, and the various proverbs, 'The observations of the many set forth by the wit of one,' are scientifically explained, and either confirmed or refuted. It would, in our opinion, have been preferable had this part of the book been very considerably extended; instead of only eight pages out of thirty-eight being devoted to this popular and non-instrumental part, it might at least have been expanded into three times the space with a corresponding abridgment of Parts II. and III. Part II. deals with the relations of pressure and winds, not only in our immediate neighbourhood, but in all parts of the globe, and very pretty and interesting examples of the cyclones and anti-cyclones are given, together with the circulation of the winds round these centres; but throughout the whole of this part there appears to be a more or less general reproduction of the matter which was given to the world in Mr. Scott's Weather Charts and Storm Warnings, and the whole of this division pre-supposes the possession of the weather charts, and the time to study them.

Part III. gives us again a quantity of useful and popular information as to changes which may, and do actually take place over our heads; and at the conclusion specimens are given of the sort of forecast which an observer can make, even *without the aid of the weather-maps*, a desideratum which cannot be too strongly insisted on. At the conclusion, the author has given two maps of the mean atmospheric pressure and prevailing winds for the months of January and July, the principal phenomena in which are noted in the chapters on those subjects. Speaking about these charts, he says that we find areas of low pressure around the poles, but this does not appear to

be so in the January chart in the case of the North Pole; and the fact that north-east winds are reported from Iceland and Greenland, proves the existence of high pressure in the high latitudes.

Turning to Mr. Lowe's pamphlet, we find that he starts with the assumption which every meteorologist seems so disposed to admit, yet finds so difficult to substantiate, viz. that a cycle of the seasons exists, though its precise period has yet to be ascertained. Mr. Lowe himself is satisfied that the cycle is about eleven years, thus agreeing with the Sun-spot theorists (though throughout the book there is no reference to sun-spots, or to this agreement), while at the same time he considers that at every ninth cycle the phenomena are much intensified.

An extraordinary amount of trouble has undoubtedly been expended in the compilation of this work, and the authorities being quoted, an immense assistance is thereby afforded to any one continuing the investigations. That further investigations are needed is, unfortunately, most true, for we find that during the past six centuries fifteen droughts were accelerated one year, and nine were retarded one year, while six were accelerated two years, and four retarded a like period. This compels us, in giving a forecast, to allow a margin of four years for possible eventualities, a margin which is much too large to give the forecast a practical value. This value may, however, very shortly be tested, as Mr. Lowe considers that with last October there commenced three years of drought and frost, a forecast which every succeeding day will go to prove or refute.

HEAT.*

PROF. TYNDALL'S well-known treatise on the mechanical theory of heat has now been out of print for a considerable time, so that the appearance of this sixth, revised and enlarged edition, will be welcomed by many students. Founded as it is upon his lectures delivered at the Royal Institution, and retaining the lecture form in its chapters, while the numerous experiments which the Professor delights to bring before his audiences are copiously illustrated by figures of apparatus in use, the style in which the information is conveyed to the reader has a freshness and vigour about it hardly attainable by any drier mode of treatment, and one is at no loss to understand the great popularity that this book has so long enjoyed. In his new edition Prof. Tyndall has evidently been careful to work in the most recent results of physical researches in the somewhat wide field that he undertakes here to open up to his readers, his book, as is well known, discussing a host of phenomena with which heat is more or less immediately concerned.

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* *Heat a Mode of Motion.* By John Tyndall, D.C.L., LL.D., F.R.S. Sixth Edition. 8vo, London: Longmans, 1880.

FLOWERS.

WE have received two little books intended to aid the student during his earlier steps in the practical study of botany. One of these is a pamphlet* for the use of beginners, and for teachers in schools, arranged somewhat on the same model as a small book by Mr. Henslow, which we noticed some time since. The author, Dr. Andrew Wilson, has selected the following illustrations of floral structure,—the buttercup, wallflower, primrose, apple, dead nettle, tulip, daffodil, iris, pea, and daisy; and his explanation of the structure of these, and of the mode in which it may be investigated, is exceedingly simple and clear. In a concluding section he notices the conditions which modify flowers, and gives examples of schedules for filling up with the characters of those examined by the student, followed by a brief lesson on the general physiology of the plant, which contains a great amount of useful information in a very small space.

The second book† is of a more ambitious character, and is intended for the behoof of more advanced students. It consists essentially of a series of analytical tables of the natural order and genera of British flowering plants and ferns, arranged on a peculiar principle:—The left hand page in each opening contains a table of symbols indicating the floral character, and those of the leaves and fruit, with the name of the order or genus thus illustrated; on the opposite page we find brief characters of the respective groups, with the English name of the type form. These tables are preceded by a short glossary of terms, and followed by a table showing the numerical strength of the different natural orders in the British flora, and by a catalogue of the species of British plants.

It is a somewhat curious experience to be set to read the characters of plants by means of a system of picture-writing, and in examining the book one feels at first a little puzzled to know what some of the symbols mean; but on further examination the rough places become smooth, and we have no doubt that Mr. Messer's book will prove a considerable boon to young students of botany. Of course the figures are all purely diagrammatic: but the book is very nicely printed and got up.

PURE AND APPLIED MATHEMATICS.‡

THIS is, for the most part, a carefully edited print of the note-book of a teacher of mathematics. Its leading idea is undoubtedly that of a repetition book for 'cramming,' and it seems to us that it is not only well adapted

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* *Introduction to the Study of Flowers, being Practical Exercises in Elementary Botany.* By Andrew Wilson, Ph. D., F.R.S.E. 12mo. Chambers: London and Edinburgh, 1880.

† *A New and Easy Method of Studying British Wild Flowers; Being a Complete Series of Illustrations of their Natural Orders and Genera, analytically arranged.* By Frederic Messer. 8vo. London: David Bogue. 1880.

‡ *A Synopsis of Elementary Results in Pure and Applied Mathematics.* By G. S. Carr, B.A. London: C. F. Hodson & Son. Vol. I. part i. (xxiv. and 256).

for this its main purpose, but that it would be doing it some injustice to call it a mere cram-book. The author's notion was to supplement the use of the ordinary text-books, with the view of assisting the student in the task of revision of book-work, and, in the author's own words, 'To this end I have, in many cases, merely indicated the salient points of a demonstration, or merely referred to the theorems by which the proposition is proved. I am convinced that it is more beneficial to the student to recall demonstrations with such aids, than to read and re-read them. Let them be read once, and recalled often.' This is a sound view of mathematical teaching, whether the object of that teaching be a mere cram for a tripos, or the preliminary grind which is necessary to all high reading.

Besides this, the author has endeavoured to make the book a general *aide-mémoire*. In this we think he has not been quite so successful, the scholastic requirements of arrangements interfering not only with the facility of reference, but also governing the subject-matter, especially in respect of that concreteness which is so necessary for practical uses, and so much out of the direct line of usual instruction. As a work of reference it is not so well planned as another Synopsis by another Mr. Carr, of which a second edition was published by Weale in 1843.*

With a view of making the book one of reference, there has been prefixed to it a chapter containing an account of the centimètre-gramme-second system of units, and some mathematical tables, chiefly in very short abstract, but with two tables fully given—a factor table from 1 to 99,000, reprinted from Burckhardt, and a table of the Gamma function, reprinted from Legendre. This set of tables does not appear to us to be very well selected or arranged, nor to be of much utility. Moreover, as the first volume is concerned exclusively with pure mathematics, the physical units are rather out of place in it, and might advantageously have been reserved as an introduction to the applied mathematics which are to be included in the second volume.

The part before us includes algebra, the theory of equations, and determinants, plane and spherical trigonometry, elementary plane geometry, and geometrical conics. Of these it seems to be a well-selected synopsis, well arranged too for its chief purpose as a book of repetition, and containing a good number of useful theorems, especially in the algebra, which are not usually to be found in the books of elementary reading. Among them we note Gauss's resolution of a hypergeometrical series into a continued fraction, and various theorems upon equations and determinants.

The type, and paper, and the general 'get-up' of the book, are not at all to our taste. It is, however, clearly printed, and there is a good table of contents. On the whole, if the work, when complete, is supplemented by a good index, it will occupy a place not filled up at present.

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* There is a curious story about this book. It was printed in Durham some years before the above-mentioned date, and soon became out of print and scarce, although it was known that 5000 copies had been struck off. In 1842 the stock of a London publisher came to the hammer, and among the remainders were found, in sheets, 3500 copies of the work. The re-issue of these formed Weale's second edition.

THE INDUSTRIES OF INDIA.*

ON the recent disintegration of the collections which were contained in the East India Museum, all the botanical specimens were transferred to Kew, while the zoological, the mineralogical, and the architectural specimens passed to the British Museum. There remained, however, at Kensington a vast number of valuable objects illustrating the arts and industries of India, which formed in fact the most popular part of the old Museum. These objects have been transferred from the India Office to the custody of the authorities of the Science and Art Department, and they are consequently now exhibited as a part of the South Kensington collections. The transfer was primarily effected for the purpose of relieving the Indian Exchequer of the cost of maintaining a museum in London; while under the new arrangement the guardianship of the collections throws no additional burden upon the Imperial Exchequer, since it has been undertaken by the staff of keepers who already had charge of the South Kensington Museum. As soon as the Kensington authorities obtained possession of the collections they commissioned Dr. Birdwood, of the India Office, to prepare a Handbook which should form one of the series of works on art in course of issue by the Department. The result of Dr. Birdwood's labours is seen in the interesting work now in our hands.

So closely are the arts of India interwoven with the various religious beliefs of the people that no thorough appreciation of native art is possible without some familiarity with Hindu mythology. The author has, therefore, devoted the early part of his work to a description of the Hindu pantheon. In the second part he deals with the master handicrafts of India, principally with the metal-work, the jewellery, the pottery, and the textile products. This part is, to a great extent, an enlarged reproduction of the author's well-known *Handbook of the Indian Court of the Paris Exhibition of* 1878. It should be distinctly understood that the present work is not a mere Guide to the Indian Museum, much less a Catalogue of its contents. It is, in truth, a pleasantly-written book, full of information on the arts, the religion, and the social life of India—a work which may be read at home without the slightest reference to any particular collection of Indian products. In fact, if we are obliged to find any fault with so good a book, it is in the direction of discursiveness rather than of elaboration. Taking, for example, the chapter on Indian pottery we find that considerably more than half the space is devoted to a description of village-life and land-tenure in India. It should be added that Dr. Birdwood's volumes are copiously illustrated by excellent wood-engravings, but we regret that they are not furnished with an index.

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* *The Industrial Arts of India.* By George C. M. Birdwood, C.S.I., M.D. With Map and Woodcuts. 2 vols. 8vo. London: Chapman & Hall.

RAMBLES IN SEARCH OF MINERALS.*

A MOURNFUL interest clings to this little book as being the last work which issued from the active pen of the late Prof. Ansted. Perhaps no science is more difficult to popularize than Mineralogy, since its veriest rudiments cannot be understood without some scant knowledge of solid geometry and of chemistry. Notwithstanding the necessary exclusion of crystallographic and chemical expressions, Prof. Ansted has contrived to give intelligible descriptions of a number of minerals, and to convey to the reader in a pleasant gossipy way a great deal of information about their mode of occurrence. The volume forms one of a series entitled *Natural History Rambles*, but the rambles in this case must necessarily be taken rather far from home, since the principal part of the book is devoted to a popular description of gems and various ornamental stones which are not likely to be met with in any part of the British Islands. But if gem-stones be taken away, mineralogy loses nearly the whole of its popular element, and we are consequently not disposed to cavil at their intrusion into our *Natural History Rambles.*

GUTHRIE'S ELECTRICITY.†

THE critic finds his occupation gone as he reads on the title-page of this work that it has already reached the 'Fifteenth Thousand.' Such a sale is alone sufficient to show that Dr. Guthrie's text-book has been found widely useful to students of physics. Having used the work in class-teaching the present writer can testify without hesitation to its sterling worth. The work is based upon the lectures which the author has been in the habit of delivering in his annual course at the Royal School of Mines. It is to be regretted, however, that successive editions are not revised so as to keep pace with the advance of electrical science: we fail to find, for example, any reference in the Index to such subjects as the Telephone and Microphone.

THE SUPERNATURAL IN NATURE.‡

THIS very able book, published at first anonymously, has reached a second edition, and its success has determined the author to reveal himself and also to thank some well-known scientific men for their help. The object of

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* *Natural History Rambles: in Search of Minerals.* By D. T. Ansted, M.A., F.R.S. 8vo. London: Society for Promoting Christian Knowledge. 1880.

† *Magnetism and Electricity.* Collins' Advanced Science Series. By Frederick Guthrie. With 300 Illustrations. 8vo. London and Glasgow: Wm. Collins, Sons, & Co.

‡ *The Supernatural in Nature, a Verification by free use of Science.* By Rev. Joseph William Reynolds, President of Zion College. 8vo. London: C. Kegan Paul and Co. 1880.

the work is to reconcile science and Scripture; and it is written for the sake of the true lovers of science 'and other truth-loving men, who are in danger of being beguiled by the sophisms of an imperfect science.' And the author decides that physical science is the sister and handmaid of Revelation: that no lasting antagonism can exist between them, nor will man lastingly receive a religion that requires antagonism. He considers that science has not yet advanced far enough to establish perfect accord with revelation, but is tending thither; and when attained, the generalizations of science will no longer be doubtful but assured. His aim is to promote that agreement by showing the correspondence between truly scientific conclusions and Holy Writ; by exposing hasty generalizations which appear contrary to revelation, by making it plain that science is knowledge as exact as is possible to finite wisdom, and that scientific truths like the spiritual have for ever been descending from heaven to man. The author notices that the most brilliant scientific work of late years has been amongst the 'unseen,' and that the connection of all visible things with the invisible is plain enough. The multitude of inexplicables, the impossibility of comprehending ultimates, and the fact that scientific orthodoxy becomes scientific heresy with the progress of induction and observation, together with the vast unknown, all tend not only to make the true student of science humble, but also disposed to admit powers and energies environing everything and beyond the ken of nature.

The book is full of most accurate scientific statement, and the amount of physical, biological, and astronomical learning displayed is very great. No uncharitable remarks deface the work, and it is written in a grand style which often rises to great eloquence. There is no other book of the kind, and it must be most valuable to the preacher who will condescend to instruct his hearers on something else than dogma, and to the conscientious theological student.

LAND AND FRESHWATER SHELLS.*

MR. RIMMER has published an excellent little treatise upon the Land and Freshwater Shells of the British Isles, and one which will, doubtless, be found exceedingly useful by many young students. He tells us in his preface that he has 'followed the author of *British Conchology* in the method of arrangement, as well as in the nomenclature which he has adopted;' and on the same page he acknowledges his indebtedness to the author of that work, Dr. Gwyn Jeffreys, so that we can understand the close agreement, not only in arrangement and general treatment, but actually in the wording of the descriptive parts that prevails between the two books. However, the author could hardly have followed a better model, so that his readers have certainly no reason to complain.

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* *The Land and Freshwater Shells of the British Isles.* With Illustrations of all the Species. By Richard Rimmer, F.L.S. 8vo. London: D. Bogue, 1880.

Mr. Rimmer has added localities for many of the species from his own observations, from those of correspondents, and from local lists published in journals; he has also in some cases added information on the natural history of the animals, and introduced in their proper places a few species discovered or admitted to specific rank, or admitted to British citizenship since the publication of the first volume of the *British Conchology*, so that his book may be taken as a good and trustworthy exposition of our present knowledge of the British territorial and freshwater shells. We notice one curious statement, however, an explanation of which would be desirable. The author says that the Sphæriidæ have the siphons placed in front, instead of at the posterior end of the body, an assertion which is rather startling.

Following Dr. Jeffreys' example, Mr. Rimmer has given the accentuation and translation of all the generic and specific names occurring in his book, and these occur again, together with the terms used in description, in a glossary appended to the work. The mode of pronunciation of the words is also indicated, in a very effective, if rather grotesque fashion.

The little book is illustrated with ten plates, giving figures of all the species, mostly reproduced from photographs by the 'Albertype process.' We must confess that, although some of the figures, especially of the larger shells, are very beautiful, and nearly all of them, except the minute ones, furnish a fair idea of the objects represented, we must still adhere to the conviction that we have entertained for many years, that photography is not adapted to produce satisfactory illustrations of natural history objects. Of two sets of species, namely, the slugs, on account of their restlessness, and the species of *Vertigo*, on account of the minuteness of the characters of the mouth, which had to be represented, the author has given good lithographed figures.

We hope that Mr. Rimmer's labours may be rewarded as he desires, by the diffusion among the people of a taste for investigating the natural objects which everywhere surround them in such profusion; and that he wll soon find in his rambles that he is no longer regarded by chance passers-by as a harmless lunatic escaped from some asylum.

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

Remains of the Stone Age near Tyre.—M. Lortet has communicated to the French Academy (*Comptes Rendus*, 16th August, 1880) the results of some explorations made by him at Hanaoueh, a small village among the mountains east of Tyre, at a distance of about two hours and a half from that place, and close to 'Hiram's tomb.' To the north of this, upon a hill are the ruins of a Phenician citadel, investigated by M. Renan, and at its base winds a wild and barren valley (Wady-el-Ahkat) deeply cut into the thick deposits of a cretaceous limestone. Following the left wall of this ravine to the eastward, M. Lortet came upon some rock escarpments, which extend for a long distance, and upon them were carved in high relief a number of small statues, from 0·80 to 1 metre in height, having all the characters of a very high antiquity. A little way from these singular monuments at the foot of an abrupt artificial face, about 4 metres in height, there were enormous blocks of a reddish rock, so hard as to be almost unbreakable with the hammer. This rock proved to be a conglomerate or breccia containing myriads of worked flints, and numerous fragments of bones and teeth. The soil all round was strewn with roughly-worked flints, among which were points and scrapers of the so-called Moustierian type. The flints are yellow or black, and of very fine grain; those in the blocks are often exposed at the surface by the action of the weather, but the rock is so excessively hard that it is almost impossible to detach them from the gangue, and they break rather than separate from the cement that holds them together.

A few fragments of teeth extracted from this intractable matrix are considered by M. Lortet to indicate the genera *Cervus*, *Capra* (or *Ibex*), *Bos*, and *Equus*. M. Lortet remarks that this station seems to date from the most remote antiquity. The flints present a very primitive form, much more archaic than those found in the caves of the Nahr-el-Kelb, near Beyrout, and a long series of centuries would be necessary to give to these kitchen remains a hardness equal to that of the most compact porphyry. He think sthat this matrix must have been formed in a cavern, the roof and walls of which were subsequently removed by the Proto-Phenicians, who

worked the rude figures above mentioned. The breccia, being too hard for their tools, was left by them exposed as it is now found. M. Lortet does not, therefore, regard the makers of the flint implements and the artists of the statues as one and the same people; and he remarks that it is interesting to find here within a very limited space the traces of three races which have successively inhabited the country, namely, palæolithic man, the Proto-Phenicians, and the Phenicians of historic times, whose works abound in the neighbourhood.

An extra Bone in the Human Wrist.—Dr. Eugène Vincent has found an additional (ninth) bone in each wrist of an old Arab. The first row of carpals consisted, as usual, of four bones, but the second row had five; the supplementary bone, which was equal in size to the pisiform, was between the trapezium and the grande, and it was applied against the scaphoid above and the trapezoid in front, but articulated by one of its faces with the second metacarpal. The structure was the same in both wrists. The Orang and most of the lower Apes regularly possess a ninth bone in the carpus, but this differs somewhat in position from the bone found by Dr. Vincent, and does not appear to reach the second metacarpal bone which is nearest to it. In the Quadrumana, Cuvier considered the supplementary bone to be a separated portion of the grande; but according to the opinion of M. Alix it is rather a dismemberment of the scaphoid. Dr. Vincent regards the ninth bone in his Arab as probably derived from the trapezoid, which was much reduced in size.—(*Compte Rendu de l'Assoc. Franç.*, 1879.)

ASTRONOMY.

Secular Acceleration in the Mean Motion of the Moon.—At the April meeting of the Royal Astronomical Society, Sir George Airy read a paper on the 'Theoretical value of the Acceleration in the Moon's Mean Motion in Longitude, produced by the change of Eccentricity of the Earth's Orbit,' in which he advanced the opinion that the true value of this acceleration was really 10″·1477 per century, and not 6″·18 as generally supposed by astronomers. The true value of the acceleration in the mean motion of the Moon produced by the gradual diminution in eccentricity which the Earth's orbit is undergoing, is a question which was warmly discussed by astronomers some twenty years ago, but which has been considered definitely settled for the last fifteen years, so that Sir George Airy's paper created much surprise. The whole question is purely a mathematical one; it can only be settled by mathematical analyses, and is one about which there ought to be no doubt. The existence of a gradual acceleration in the motion of the Moon had been known for a long time, but the explanation of its origin had been sought in vain by astronomers, until it was discovered by Laplace that the diminution of the eccentricity of the Earth's orbit would produce such an acceleration. Laplace calculated its value approximately, omitting a number of terms which seemed too small to be sensible, and found it to be equal to 10″·1816 per century, which was in perfect accord with that which seemed

indicated by the observations, namely, 10″·3. The agreement was so close, that Laplace did not consider it necessary to push his calculations any further. Subsequently other astronomers did push the calculation further, taking into account a number of small factors omitted by Laplace, and found 10″·63 for the theoretical value, and 10″·8 for the observed value. In the year 1853, a remarkable paper was communicated to the Royal Society by Prof. J. C. Adams, and in this memoir it was clearly shown that these later astronomers had taken into account only a portion of the terms omitted by Laplace, and had entirely overlooked a most important class of these additional terms. Taking all these into consideration, Prof. Adams showed that the real value of this acceleration produced by the variation in the eccentricity of the terrestrial orbit, was only 6″·20. For some time Prof. Adams' paper did not excite the attention it deserved; but during the period 1858 to 1863, Prof. Adams' investigation was warmly discussed by all the leading masters of the lunar theory. In the end, the correctness of Prof. Adams' results were unanimously admitted by all, and independent proofs were furnished by, amongst others, M. Delaunay and Prof. Cayley. For the last fifteen years, therefore, it has been generally admitted by astronomers that Prof. Adams had conclusively established the correctness of his views. It is true that the researches of Prof. Hansen seemed to show that the observations indicated an actual acceleration of over 12″·2, but it was known that the whole of this acceleration did not necessarily proceed from the diminution in the eccentricity of the Earth's orbit.

Although Sir George Airy made no reference to Prof. Adams in his paper, it was obvious that the paper could only be regarded as a direct attack on Prof. Adams' views; for if Sir George Airy was correct, then Prof. Adams was as certainly wrong. Naturally, therefore, the publication of Sir George Airy's paper was waited for with impatience by astronomers, who were curious to see the grounds on which Sir George Airy had been led to impugn the correctness of the unanimous opinion of all the greatest authorities on the lunar theory. The paper was published in the beginning of May, and must have been read with astonishment by astronomers. The importance of this question is far too great to permit of any doubt being allowed to remain as to the truth, so that, although Sir George Airy disclaimed any wish to raise a controversy on the matter, it was absolutely indispensable that the real truth should be at once made known. Everyone looked, therefore, to Prof. Adams for a reply. This Prof. Adams lost no time in sending in to the Royal Astronomical Society, where it was read at the May meeting and published in the middle of June. In this reply, Prof. Adams points out that Sir George Airy has misunderstood the nature of the results which he had arrived at in his investigation; and that, instead of the value deduced by Sir George Airy being the complete value of the secular acceleration as he supposed, it was only a portion of the whole. Prof. Adams further showed that Sir George Airy had neglected as insensible, or else omitted as unimportant, all the very quantities which had been shown by Delaunay, Cayley, and himself to have so important an influence on the value of the secular acceleration; and that, in fact, Sir George Airy had, without suspecting it, practically arrived in a roundabout manner at the same approximate result as was obtained by Laplace nearly a century earlier,—a result long

known to be quite imperfect. At the June meeting of the Royal Astronomical Society, Prof. Adams communicated a further paper containing a proof in an elementary form of the accuracy of his own value, impugned as incorrect by Sir George Airy. This paper was published in the middle of August. Although some rejoinder may be looked for from Sir George Airy, there can be no doubt, after Prof. Adams' conclusive reply, that the Astronomer Royal has been led into error by the form he has given to his investigations.

A singular point in this controversy may be mentioned. There has always been a desire to reconcile the observed value of the acceleration in the motion of the Moon with that arising from the diminution in the eccentricity of the Earth; but whereas the former seemed to amount to over 12″·2, the latter was only 6″·2. It was this discrepancy which probably led Sir George Airy to take up the subject. But quite lately the researches of Prof. Newcomb have clearly shown that this value of 12″·2 is a great deal too large, and arises from an error in Hansen's Tables of the motion of the Moon. Correcting this error, Prof. Newcomb is able to show that the secular acceleration is probably less than 8″·3. It has been shown, subsequently, by Mr. Neison, that if one of the most discordant of the ancient eclipses be omitted, all the rest are in harmony with the value of the secular acceleration of 7″·2, and are more in harmony with the value 6″·2 than with any value greater than 8″·0. It is not at all improbable, therefore, that before long further improvements in the lunar theory will reconcile the observations with Prof. Adams value of the secular acceleration, and that Sir George Airy's value, instead of reconciling theory and observation, as he supposed, would have thrown them into intolerable discord.

Record of the Progress of Astronomy during the year 1879.—Under this title there has been compiled by Mr. J. L. E. Dreyer, M.A., of the Observatory of Trinity College, Dublin, a very useful account of the principal astronomical events of the past year, and it has been published as a memoir by the Royal Dublin Society in their *Scientific Proceedings*, and reprinted therefrom in an octavo pamphlet of some fifty pages. Mr. Dreyer prefaces his summary as follows:—'In the following pages I shall endeavour to sketch the principal astronomical events of the past year, giving short accounts of the more important or interesting investigations which have been published during this period. For the year 1878, such an account was written by Prof. E. S. Holden, of the United States Naval Observatory, for the *Annual Record of Science and Industry;* and as I have learned from him that this publication has been discontinued, I have thought it might be of some use, both to professional astronomers and to amateurs, if a continuation of his record was kept up, giving summaries of the work done in the various branches of Astronomy, merely intended to draw attention to what has been done in them. It had at first been my intention to add to this review a bibliographical list of books and memoirs in Astronomy published during 1879, but for various reasons I have left it out. It might be better to let such a list embrace a longer lapse of time than one year; and, besides, the *Bibliographie Générale*, the publication of which has recently been announced from the Brussels Observatory, is to include the year 1880. The present record does not aim, therefore, at any completeness, but only at

giving a brief account of a number of memoirs and papers which have appeared to me to possess more than a passing interest.' Mr. Dreyer's summary will certainly be found of great use to all astronomers; and it is to be trusted that in the interest of Astronomy its compiler will see his way to rendering it an annual publication. There are few things which a scientific man requires more than a compact record of the principal work achieved during the year—a record giving not only a general idea of the contents of a paper or a memoir—the mere title is of far less value—but the publication wherein it appeared. Mr. Dreyer divides his record into the following seventeen heads:—1. Spherical Astronomy; 2. Theory of Instruments; 3. Celestial Mechanics; 4. The Sun; 5. The Moon; 6. The Intra-mercurial Planet Question; 7. Planets and Satellites; 8. Comets; 9. Meteors and Meteorites; 10. Fixed Stars; 11. Annual Parallax: 12. Double Stars; 13. Nebulæ and Clusters; 14. Photometry; 15. History of Astronomy, Bibliography; 16. Observatories; 17. Miscellaneous Notes.

Figure of Mars.—During the last opposition of *Mars* in November 1879, Professor C. A. Young made a numerous series of measures of the diameter of the planet with a parallel wire micrometer, on the 9½-inch Alvan-Clark Equatorial of the Princetown College Observatory. From a careful discussion of these observations, Prof. Young deduces the following value for the apparent equatorial and polar diameter of the planet on November 12, 1879:—

Equatorial diameter of Mars .	= 20″·634	± 0″·034
Polar diameter of Mars . .	= 20·552	± 0·043
Mean diameter of Mars . .	= 20·593	± 0·035

These measures, being made with a parallel-wire micrometer, must be affected by the constant error due to irradiation at the edge of the planet, the irradiation being principally due to the spurious disc into which every point of light is converted by the telescope. Prof. Young points out that if we adopt as the true value of the diameter of the planet *Mars* at the distance unity from the Earth, the value 9″·352 deduced by Hartwig from all the measures prior to 1879, the real value of the diameter of *Mars* on November 12, 1879, must have been 19″·128. The difference 1″·465, between this and the value found by Prof. Young, which was 20″·593, is regarded by him as being due to irradiation. This is larger than that due merely to the spurious telescopic diffraction disc, which would amount to about 1″·0. Prof. Young points out that the value found by him for the mean diameter of *Mars*, when reduced to distance unity, is 10″·068.

Prof. Young then utilizes these measures to determine the figure of the planet. The difference between the apparent polar and equatorial diameter is 0″·0818, which would correspond to a compression or ellipticity of 1 ÷ 234. But as Prof. Young points out, at the time of measurement the pole of *Mars* was not really on the periphery of the planet, but was 14°·5 from it, so that the apparent polar diameter was greater than the real polar diameter. Allowing for this, Prof. Young deduces 1 ÷ 219 as the actual polar compression of the planet *Mars*. As Prof. Young points out, this is in close accord with the value 1 ÷ 228 deduced by Prof. J. C. Adams for the polar com-

pression of *Mars* on the assumption that the internal constitution of the planet follows the same law as that of the Earth.

On the Brightness and Dimensions of the Satellites to the Planets.—For some time Professor Edward C. Pickering, of the Harvard College Observatory, has been engaged in a series of important photometric investigations; and in Part 2 of Vol. XI. of the *Annals of the Harvard College Observatory*, he has published the results of the observation of the brightness and size of the satellites of the planets.

Mars.—The inner satellite of *Mars*, *Phobos*, is fully 0·3 magnitude brighter than the outer satellite *Deimos*, and *Deimos* is in turn 14·5 magnitudes fainter than the brightness of the central portion of the disc of *Mars*. *Deimos* seems to be variable in brightness, being fully 0·5 magnitude brighter when on the following side of the planet, than when on the preceding side. Assuming that the satellites reflected as much of the incident light as *Mars* itself, Prof. Pickering deduces 6 and 7 miles as the diameter of *Deimos* and *Phobos*, or less than 0″·05 for their maximum apparent diameter. According to Prof. Pickering, a certain amount of light is not prejudicial to the visibility of these faint objects.

Jupiter.—Observations were made of the brightness of the satellites, by comparing them with the planet itself, and from the amount of light they reflected, their apparent size was calculated on the hypothesis that they reflected the same proportion of the incident light as the planet. The results were—

	I. Satellite.	II. Satellite.	III. Satellite.	IV. Satellite.
Photometric diameter	0″·873	0″·818	0″·035	0″·615
Measured diameter .	1·081	0·910	1·537	1·282
Albedo . . .	0·652	0·809	0·455	0·230

Or, in other words, the satellites of *Jupiter* reflected only two-thirds, four-fifths, four-ninths, and one quarter of the same proportion of incident light as the planet itself reflects, while this is known to be only six-tenths of the total light falling on the surface. These results are in complete accord with the known phenomena presented by the satellites.

Saturn.—Observations were made of all the satellites of *Saturn*, with results as follows, namely, that the comparative dimensions of the different satellites were, as given below, on the assumption that all reflected the same proportion of the incident light:

Mimas . . .	292 miles.
Enceladus . . .	370 „
Tethys . . .	570 „
Dione . . .	542 „
Rhea . . .	745 „
Titan . . .	1406 „
Hyperion . . .	193 „
Japetus . . .	486 „

If, therefore, *Titan* be taken as usually shining like an 8½ magnitude star, the brightness of the different satellites may be approximately considered to be—

Mimas	12·0	magnitude	(Argelander)	14½	magnitude	(Herschel.)
Enceladus	11·4	„	„	13	„	„
Tethys	10·5	„	„	11½	„	„
Dione	10·8	„	„	12	„	„
Rhea	9·9	„	„	10½	„	„
Titan	8·5	„	„	9	„	„
Hyperion	13·0	„	„	17	„	„
Japetus	10·8	„	„	12	„	„

Japetus is, however, very variable in brightness, being at one part of its orbit more than three times as bright as at another part. Prof. Pickering points out that if this variation in brightness is due to the unequal brightness of the two hemispheres of the satellite, the satellite must always turn the same face to the planet exactly as in the case of our Moon. *Mimas* and *Enceladus* look fainter than they really are, owing to their proximity to the planet.

Uranus.—The comparative diameters of the two brighter satellites are—

Titania . . .	586 miles.
Oberon . . .	544 „

The two minor satellites were too faint for measurement.

Neptune.—The comparative diameter of the satellite of *Neptune* is—

Satellite . . .	2260 miles.

It is thus one of the largest of the secondary members of our solar system.

The suspected Ultra-Neptunian Planet.—No results have been made known with respect to the distant planet believed by Prof. George Forbes to be at present close to the star *β Virginis*. It is probable, therefore, that no attempt has been made to search for this very problematical planet. It will be remembered that Prof. Forbes founded his belief in its existence on a study of the orbits of the different comets of long period, and that he assigned a distance from the Sun of over 100 times that of the Earth, and a period of over 1000 years. Prof. Forbes also pointed out, that in 1857 this supposed planet would be in the position of the star No. 894 in the Greenwich First Seven-Year Catalogue, a star which was only seen in the year 1857, and on no subsequent occasion. We now learn that this star, No. 894, was a tenth-magnitude star, observed by mistake for one of the minor planets, and that it still remains in its place. The hypothesis of Prof. Forbes that this might be his planet therefore falls to the ground. As before pointed out, if Prof. Forbes's planet really existed, it would probably be so faint (like a fourteenth-magnitude star), and would move so slowly that it could not be detected without enormous labour with an exceeding powerful telescope.

Faye's Comet.—This comet was detected by Mr. A. A. Common with the 37-inch reflector of the Ealing Observatory, on the night of August 2nd, very near to the position assigned to it in Dr. Axel Möller's Ephemeris. The comet was very small and faint, so that, although it does not pass its perihelion passage until January 22nd, 1881, it is probable that it will not be seen with any except the few very powerful instruments which are now in existence.

Discovery of Two New Planetary Nebulæ. — In a communication to *Nature* (August 5th, 1880), Prof. Edward C. Pickering, of the Harvard College Observatory, announces the discovery of two very small planetary nebulæ. The one discovered on July 13th, is in R.A. $18^h\ 25^m{\cdot}2$, and Decl. $-25°\ 13'$; and the second, discovered on July 14th, is in R.A. $18^h\ 4^m{\cdot}3$, and Decl. $-28°\ 12'$. Both are very minute, and can only be distinguished from stars of about the tenth magnitude by their spectra. Prof. Pickering points out that all attempts which have hitherto been made to determine the parallax of a planetary nebula have been foiled by the uncertainty in determining the exact centre of these bodies, or by the haziness of their borders, but the minuteness of the disc presented by the two newly observed nebulæ would permit of their places being determined with the same accuracy as a star.

BOTANY.

Classification of Cryptogamia. — At the recent meeting of the British Association, Mr. A. W. Bennett laid before the Biological Section a proposed modified classification of the Cryptogamia. He remarked that in Sachs' most recent classification, the Thallophyta (including the Characeæ) are divided into four classes, namely, Protophyta, Zygosporeæ, Oosporeæ, and Carposporeæ. In his proposed classification, Mr. Bennett removes the Characeæ altogether from the Thallophytes as a distinct group. The Thallophyta are then divided into three primary classes, namely, Protophyta, Fungi, and Algæ. The Protophyta are divisible into two sub-classes, *Protomycetes* and *Protophyceæ;* the former including only a single order, the *Schizomycetes;* the latter consisting of the Protococcaceæ (including Palmellaceæ and Scytonemeæ), Nostocaceæ, Oscillatorieæ and Rivularieæ. The *Myxomycetes* are treated as a supplement to the Protophyta.

The Fungi include three sub-classes: the *Zygomycetes* composed of the Mucorini alone; the *Oomycetes*, containing the Peronosporeæ and Saprolegnieæ; and the *Carpomycetes*, comprising Uredineæ, Ustilagineæ, Basidiomycetes, and Ascomycetes, the Lichens being included in the last as a sub-order.

The Algæ also form three sub-classes corresponding with those of the Fungi, namely, the *Zygophyceæ*, including the orders Pandorineæ, Hydrodictyeæ, Confervaceæ, Ulotrichaceæ, Ulvaceæ, Botrydieæ, and Conjugatæ (under the last of which we have the Desmids, Diatoms, Zygnemaceæ, and Mesocarpeæ); the *Oophyceæ*, comprising Volvocineæ, Siphoneæ, Sphærophyceæ, Œdogoniaceæ, Fucaceæ, and Phœosporeæ; and the *Carpophyceæ*, including only the Coleochæteæ and Florideæ.

The Characeæ, as already stated, are regarded as forming a distinct primary group. The Muscineæ are retained in the same sense as by Sachs. In the case of the Vascular Cryptogamia, Mr. Bennett proposes to adopt the primary distinction into Isosporia and Heterosporia as most in accordance with probable genetic affinities. The former include the Filices, Lycopodiaceæ and Equisetaceæ; the latter the Rhizocarpeæ and Selaginellaceæ.— *Nature, 9th September.*

CHEMISTRY.

Formation of Ozone during the Evaporation of different Liquids.—When it is desirable to show a number of persons that ozone is formed during the evaporation of a liquid, Böttger (*Polyt. Notizblatt*, xxxv. 95) recommends letting fall on a piece of paper which has been uniformly saturated with a solution of starch and iodide of cadmium some drops of alcohol or ether, and the igniting of such solution. The paper in consequence of the ozone which is formed by the evaporation acquires a dark blue colour.

Compound of Phosphoric Hydride and Chloric Hydride.—This compound is easily prepared according to Lemoine (*Bull. Soc. Chim. Paris*, xxxiii. 194), by placing the two gases in a U-tube, one end of which is closed, under a pressure of two atmospheres, produced by a column of mercury in an open tube and exposing the apparatus to the cold of liquid sulphurous acid, the evaporation of which is increased by a strong current of air.

Silver Trioxide.—By the electrolysis of silver nitrate a curious body is formed, first described by Ritter in 1804, and later by Grothus, which was first regarded as silver dioxide, but has since been shown to contain nitric acid. Berthelot has since examined it (*Compt. Rendus*, 1880, xc. 653). He employed a battery of four Bunsen elements during twenty-four hours, and obtained a gramme of the body. Washed and dried it presented the appearance of thick, short, flattened needles with metallic lustre, which soon fall to pieces and lose their lustre. It develops oxygen rapidly at 100°. Analysis gave the formula $4\,Ag\,O_3$, $N\,O_6\,Ag$, $H\,O$ (old formula!). The longer it lies the higher rises the percentage of silver, and the composition approaches the formula $N\,O_6\,Ag + 4\,Ag\,O$.

Salireton.—Experiments have been made by P. Giacosa (*Journ. prakt. Chem.* 1880, xxi. 221), to prepare glycosides synthetically, and led him to heat saligenin and mannite to 100°. In this way he obtained a new product of condensation of saligenin $C_{14}\,H_{12}\,O_3$, which he has termed salireton. The same body is formed when glycerin or methylal is taken in place of mannite: and its formation is thus explained:

$$2\,C_7\,H_8\,O_2 - H_2\,O - H = C_{14}\,H_{12}\,O_3.$$

The curious phenomenon that during the formation of this body, not only water but hydrogen also should be extruded, led the author to think that perhaps, in the first instance, a molecule of saligenin might be oxidized to salicylaldehyde, which then first combined with a second molecule of saligenin to salireton, water being extruded, as shown below:

$$C_7\,H_8\,O_2 + C_7\,H_6\,O_2 = C_{14}\,H_{12}\,O_3 + H_2\,O.$$

Although when saligenin was heated with glycerin the odour of salicylaldehyde could not be recognized, the author heated equivalent quantities of salicylaldehyde and saligenin, just like the saligenin and glycerin, in closed tubes in boiling water. After many hours' heating, the contents of the tubes were treated with water and distilled; with the steam almost the whole of the salicylaldehyde passed over; the resinous residue remaining in the retort was boiled with a little water and filtered. From this filtrate the salireton separates: this is recrystallized, and when pure melts at 121°·5. The yield

of salireton was far less than when saligenin is heated with glycerin or methylal. In any case the salicylaldehyde, like the glycerin, plays the part only of a liquid of suspension. The salireton melts at 121°·5, gives off gas at 140° as well as the odour of salicylaldehyde, while a black resinous residue remains. An examination of this residue showed it not impossible that this contained saliretin $C_7 H_8 O$ (?). For the formation of the latter body the following reaction may perhaps take place:

$$\underset{\text{Salireton.}}{C_{14} H_{12} O_3} - \underset{\text{Salicylaldehyde.}}{C_7 H_6 O_2} = \underset{\text{Saliretin.}}{C_7 H_6 O}$$

Recognition of Mercury.—Jüptner employs the iodide $Hg I_2$, which, as is well known, is dimorphous, occurring in yellow rhombic crystals as well as scarlet square octohedra (*Oest. Zeitung*, 1880, xxviii. 92). The latter modification, in which mercury is obtained in the wet way, as well as by touching the yellow body produced by sublimation, possesses the property of appearing quite white in the light of the sodium flame. The author studied the appearance of various colours under such conditions, and examined a series of yellow, red, green, and blue colours by the light of sodium and lithium, and found that none of them were affected in the same manner as by mercury biniodide. It forms a means by which mercury can be recognized with certainty.

Production of Alcohol by an Electric Current.—Berthelot's experiment was recently conducted in the following manner: A battery of eight Bunsen elements was connected with an oscillating conmmutator, so that from twelve to fifteen currents were sent in alternate directions per second, which were conducted to two electrodes of spongy platinum. The platinum cylinder was placed in acidulated water, and the contact-action so arranged that neither oxygen nor hydrogen were given off, but the decomposed water regenerated as rapidly as it had been split up. When all had thus been arranged, the two electrodes of the apparatus were immersed in a watery solution of glucose. In this way alcohol was obtained, although it is true in but small quantity. It is hoped, however, by modifying the apparatus that the process may be improved and even made of technical importance.—(*Chem. Central Blatt.*, 1880, 288.)

Remarkable Behaviour of Tin Chloride and Potassium Chlorate.—According to Böttger (*Polytechn. Notizblatt*, xxxv. 96), when two parts by weight of tin chloride and one of potassium chlorate are rubbed together (they must previously have been rubbed fine in a porcelain mortar) the mass becomes strongly heated in a few seconds; chlorous acid and a large quantity of vapour of water are given off. The residue is a yellowish-white mass which dissolves in boiling water, and, on cooling, gives splendid brilliant mica-like crystals of potassium perchlorate, the supernatant opalescent, milk-like liquid containing the oxychloride in solution.

The Tannic Acid of Oak Bark.—C. Etti prepared the acid from the product of extracting oak-bark with alcohol by digesting it with acetic ether, in which it is soluble. He obtained a reddish-white amorphous powder, the analysis of which led to the formula $C_{17} H_{16} O_9$ as that of the body. From it, by heating it to 140°, or by boiling its aqueous solution with dilute acids, three anhydrides were obtained. The first anhydride is $C_{34} H_{30} O_{17}$, the second is $C_{34} H_{28} O_{16}$, and the third anhydride $C_{34} H_{26} O_{15}$: the first is identical with the natural phlobaphen of oak-bark, the third with Oser's 'oak-

red.' From the tannic acid, by heating it with acids in closed tubes, only gallic acid as well as 'oak-red' were obtained. If this operation be performed with hydrogen chloride, the development of a gas, which burns with a green flame (methyl chloride), is observed. The dry distillation of tannic acid yielded a small amount of brenzcatechin and a mixture of oily products, in which, very probably, the presence of dimethylbrenzcatechin was remarked. When fused with potassium hydrate there are formed, as Grabowski has shown, protocatechic acid, brenzcatechin, and phloroglucin. Digested with emulsion, or boiled with dilute acid, it yields no sugar-like bodies. It cannot, however, be regarded as glycoside—a conclusion which will already have been arrived at, from the numbers indicating an anhydride. (*Wien Anz.* 1880, 61.)

The Passivity of Iron.—If a bright piece of iron be dipped into nitric acid of 42° B, a brisk effervescence of gas takes place; this soon suddenly stops, and the metal appears bright and lustrous, and remains so. This occurs also when more dilute acid is used, down to 35° B. With the latter, also, passivity sets in after a certain time, but it does not last, and after a certain time the action begins again at a point of the surface, to suddenly stop again later on. If an iron rod be partly dipped into strong acid between 42° and 35° B, and then it be brought, with very great care, into more dilute acid, the already moistened part first, and then the upper part of the rod is slowly introduced, no action takes place at first; after some time some bubbles are seen to form on the metal, which soon suddenly cease to be developed, the rod becomes passive, and has become so because the rod had been dipped partly into strong acid. This condition has, however, no great stability; a slight shaking is sufficient to bring about a change. The degree of passivity produced in this manner is variable, and, in fact, is the smaller, the more dilute the second acid, the rougher the surface of the metal, and the greater the diameter of the rod. As soon as the metal is brought into a concentrated acid chemical action takes place. The bubbles of gas generated by the action are at first readily dislodged from the metal and are taken up by the surrounding liquid. This solubility, however, is limited, and the bubbles of gas remain adhering by capillary attraction to the metal, forming a protecting coat, which, however, can be dislodged by shaking. If the acid, however, is less concentrated—say 36° B.—the phenomenon is intermittent, because the coating is dissolved after some time, and a new one will then be formed. In the experiments with the partly immersed iron, the action of the adhering film of gas is propagated by the slow immersion of the iron slowly upwards, and exercises an attraction on the newly-formed bubbles, whereby the coating is continued from one part to another. In order to determine the influence of the dilution of the acid on the duration of the passivity, the author, L. Varenne (*Compt. Rendus*, 1880, xc. 998), made specimens of iron passive, and introduced them into acids of different degrees of dilution, as below:—

In an acid of	34° B,	the passivity of iron	ceased after	11 days.
„	32° B,	„	„	5 „
„	30° B,	„	„	32 hours.
„	28° B,	„	„	26 „
„	25° B,	„	„	24 „
„	20° B,	„	„	12 „

When the experiments were conducted *in vacuo* the same rule held good, the passivity ceasing a little earlier.

GEOLOGY.

Fossil Vertebrates from the Eocene of Champagne.—Dr. Victor Lemoine has devoted much attention to the remains of vertebrate animals found in the Eocene deposits of the neighbourhood of Rheims, from which he states he has obtained indications of over a hundred new species. Of these about forty are Mammalia, representing the Carnivorous, Insectivorous, Rodent, and Pachydermatous types. Of Birds, he has five species, some of them large, and presenting certain characters which approximate them to Reptiles; whilst, on the other hand, certain of the Reptilian bones present more or less avian characters. The Fishes, also, are said to offer a remarkable approach to the Reptiles. In the case of the Mammalia, he remarks that their predominant peculiarity is that they present mixed types, and the complexity of this mixture is greater in proportion to the antiquity of the animal. His Carnivora are complex types, having resemblances with Pachyderms, Lemurians, and Marsupials. The dentition in *Arctocyon*, of which Dr. Lemoine has two new species, presents a sort of combination of that of the Ursidæ and that of the Porcidæ, especially *Entelodon;* whilst the form of the cranium, the inclination of the angle of the lower jaw and the perforation of the humerus seem to be Marsupial characters, and the caudal vertebræ are somewhat analogous to those of the Lemurs. In the strictly carnivorous group, M. Lemoine places a new genus, *Hyænodictis;* whilst a *Proviverra* represents the less carnassial Canidæ and Viverridæ. Some small mammals, apparently organized for climbing, may have resembled the lemurs of Madagascar, as would appear from the dentition of some of them, which, however, is varied so that while certain species appear to have been insectivorous, others were probably frugivorous, and others again fitted for a mixed diet. Of these forms, which he is inclined to class under Cope's term, Mesodontes, Dr. Lemoine notices numerous species, which he refers to the genera *Protoadapis*, Lem., *Plesiadapis*, Gerv., and *Miacis*, *Diacodon*, and *Opisthotomus* of Cope. A single molar is said to resemble the same tooth in *Phenacodus*, Cope. If these determinations be confirmed, they will indicate an interesting analogy between the Eocene faunas of France and New Mexico, and a similar analogy in the floras has already been noticed by Saporta.

Two other forms appear to belong to the American group of the Tæniodontes, and present resemblances to the Mesodontes just mentioned, and to existing Rodents and Edentates. Similar analogies seem to prevail in the types M. Lemoine regards as representing the Pachyderms. The even-toed Pachyderms are represented by two species of *Dichobune*, and others, forming a new genus, *Lophiodochærus*. The Perissodactyla are more numerous, and include species of *Hyracotherium*, *Lophiodon*, and *Coryphodon*, with other forms which present very singular and varied resemblances. A molar of *Halitherium* was also obtained from the *Calcaire grossier* of Rheims.

The remains of Birds all indicate Palmipede, or Grallatorial forms.

Among them is a new species of *Gastornis* (*G. Edwardsii*). Among Reptiles, freshwater and marsh tortoises abound, belonging to the genera *Emys, Dermatemys, and Platemys*, the last now confined to the Southern hemisphere. Several species of *Trionyx* occur, and also a new type of Tortoise, resembling *Trionyx* in the granular state of its carapace, and the Emydes in the marginal plates, and the structure of the plastron. Both true Crocodiles and Alligators have left their remains in these deposits, and some of them appear to have been of large size. Among the Crocodiles one seems to approach the Gavial in the structure of the lower jaw; whilst another presents analogies with certain Secondary Crocodiles in its dental structure. Of the Lacertilian forms some have concavo-convex vertebræ; whilst others, with the vertebræ biconcave, or flat on both surfaces, would seem to belong to the Geckotidæ, a group now including only the Geckos, but more largely represented in Secondary formations. A new genus *Simædosaurus*, seems to present a combination of Lacertian and Crocodilian character, and was probably aquatic in its habits. Remains of snakes indicate that those animals may have attained a length of ten or twelve feet. The Batrachia are represented by the genus *Bufo*. The remains of Teleostian, Ganoid, and Chondropterygian fishes have been detected. Among the Ganoids the author mentions *Phyllodus, Lepidosteus*, and *Amia;* and of the cartilaginous fish he cites Chimæras, Sharks, and Rays. Remains of Mollusca, fragments of Insects, Entomostraca, and Foraminifera, together with many traces of plants, also occur in the Lower Eocene of the neighbourhood of Rheims.—(*Compte Rendus de l'Assoc. Franç.*, 1879, p. 585.)

British Fossil Cephalopoda.—We understand that the Rev. J. F. Blake, F.G.S., assisted by grants from the Government Research Fund administered by the Council of the Royal Society, has now brought the first stage of his investigations upon the British Fossil Cephalopoda to a close. He has completed his work upon the Silurian forms, which he proposes shortly to publish, prefixing to his descriptions of the genera and species a general introduction on the anatomy of the group, the structure and modification of the shells, &c. The number of Silurian species recognized by him is nearly two hundred. The work will form a volume of about four hundred 4to pages, illustrated with thirty-two plates. It will be published by subscription.

Mesozoic Mammalia.—At the close of his description of some very interesting Jurassic Mammalian remains from the Rocky Mountains (*American Journal*, September 1880), Prof. Marsh adds the following general remarks, which may be taken into consideration side by side with the facts detailed in Dr. Lemoine's account of the Mammalia of the Lower Eocene of Rheims:—

'Mesozoic Mammals have been very generally referred hitherto to the *Marsupialia*. An examination of all the known remains of American Mesozoic Mammalia, now representing upwards of sixty distinct individuals, has convinced the writer that they cannot be satisfactorily placed in any of the present orders. This appears to be equally true of the European forms which the writer has had the opportunity of examining. With a few possible exceptions, the Mesozoic Mammals best preserved are manifestly low generalized forms, without any distinctive Marsupial characters. Not a few of

them show features that point more directly to Insectivores, and present evidences, based on specimens alone, would transfer them to the latter group, if they are to be retained in any modern order. This, however, has not yet been systematically attempted, and the known facts are against it.

'In view of this uncertainty, it seems more in accordance with the present state of science to recognize the importance of the generalized characters of these early Mammals, as at least of ordinal value, rather than attempt to measure them by specialized features of modern types, with which they have little real affinity. With the exception of a very few aberrant forms, the known Mesozoic Mammals may be placed in a single order, which may appropriately be named *Pantotheria*. Some of the more important characters of this group would be as follows:—

(1) Cerebral hemispheres smooth.
(2) Teeth exceeding, or equalling, the normal number, 44.
(3) Premolars and molars imperfectly differentiated.
(4) Canine teeth with bifid or grooved fangs.
(5) Rami of lower jaw unankylosed at symphysis.
(6) Mylohyoid groove distinct on inside of lower jaw.
(7) Angle of lower jaw without distinct inflection.
(8) Condyle of lower jaw near or below horizon of teeth.
(9) Condyle vertical or round, not transverse.

'The generalized numbers of this order were doubtless the forms from which the modern specialized Insectivores and Marsupials, at least, were derived.

'Another order of Mesozoic Mammals is evidently represented by *Plagiaulax*, the allied genus *Ctenacodon*,* and possibly one or two other genera. These are all highly specialized aberrant forms, which apparently have left no descendants. This order, which may be termed *Allotheria*, can be distinguished from the previous group by the following characters:—

(1) Teeth much below the normal number.
(2) Canine teeth wanting.
(3) Premolar and molar teeth specialized.
(4) Angle of lower jaw distinctly inflected.
(5) Mylohyoid groove wanting.

'These characters alone do not indeed separate the Plagiaulacidæ from some of the Marsupials, and future discoveries may prove them to belong in that group, where they would then represent a well-marked sub-order.'

MINERALOGY.

Crystallized Danburite.—In the *American Journal of Science* for August, 1880, there is a paper by Professors Brush and Dana on the occurrence of this mineral at Russell, St. Lawrence County, New York. They received a number of specimens from a mineral collector in Northern New York, and amongst them were some prismatic white weathered crystals, which bore

* A fine jaw of which is figured by Prof. Marsh in this paper.

no name. An examination with the blow-pipe showed it to be an anhydrous boro-silicate, corresponding in physical characters with the rare species danburite. Further specimens were obtained in the spring of the present year, and these were found on further examination to establish beyond all question the identity of this mineral with danburite. It occurs both crystallized and massive imbedded in a granitic rock; the points at which it is found extend along the brow of a hill for a considerable distance, say half a mile. The crystals line cavities or seams, sometimes of very considerable size, in the massive mineral or the enclosing rock. The associated minerals are a pale-green pyroxene, a dark-brown tourmaline, and some mica, quartz and pyrites. The danburite often encloses the crystals of pyroxene and tourmaline, and is itself imbedded in the quartz, which is a point of interest in connection with its time of formation. These cavities were, doubtless, all filled originally with calcite, as the facts observed conclusively prove. A few perfectly fresh specimens were found with the crystals, imbedded in pink calcite. The perfectly pure, clear, and transparent crystals found in the calcite are of rare beauty. Most of the specimens are now nearly, or quite, free from calcite, that mineral having evidently been removed by slow solution. The crystals are thus left in their original position, projecting into the cavities. This natural removal of the calcite is in some aspects of the case an advantage, and in others quite the reverse. In no other way could the crystals have been freed from the calcite so perfectly and with so little injury to themselves; for mechanical removal is out of the question, owing to the brittleness of the mineral; and the removal by chemical means in the laboratory would not leave the crystals so nearly in their original condition. The danburite, as has been stated, is in part crystallized, in part massive. The crystals vary from those which are very minute to others which are of considerable size. The largest isolated crystals have a length of four, and a width of two and a half inches; some of the groups are really grand in their proportions. The massive mineral can be obtained in large blocks; it shows brilliant lustre, is quite unaltered, and almost free from admixed species. The most striking point in regard to the crystals is their similarity to crystals of topaz; so close is this resemblance that the specimens, if not examined too critically, might be handled many times without a suspicion that they did not belong to that species. There is, in fact, a true homœmorphic relation between the two species. The cleavage is basal, as in topaz, but not very distinct. The hardness is 7 to 7·25, and the specific gravity 2·986 to 3·021. The lustre of the polished crystalline surface is very brilliant; on the fracture and in the massive mineral it is vitreous to greasy: in this form it has much the aspect of common varieties of quartz. The colour in the freshest crystals imbedded in calcite is pale wine-yellow, in others pure yellowish-white to honey-yellow, dark wine yellow and yellowish brown. The crystals belong to the orthorhombic system; they are uniformly prismatic in habit, and it is not hemimorphic. The axial ratios are found to be, for—

	c (vert.)	$\bar{b}$	$\breve{a}$
Danburite . . .	0·8830	1·8367	1·0000
Topaz . . .	0·9024	1·8920	1·0000

The above values show that the two species are closely homœmorphous. The mean index of refraction (β) for danburite is found to be—

β = 1·634. Red (Li)
= 1·637. Yellow (Na)
= 1·646. Blue ($CuSO_4$)

In the case of the two minerals the mean indices of refraction are not far apart; thus for the D line in the spectrum we have—

β Danburite = 1·637
Topaz = 1·6138

The means of several analyses showed the mineral to have the composition given below:–

Silicic acid . . .	48·23
Boracic acid . . .	26·93
Lime	23·24
Alumina	0·47
Lost by ignition . .	0·63
	99·50

These numbers agree closely with those found by Smith and Brush when examining the Danbury mineral, and indicate the formula $Ca_2 Si O_4 + B_4 Si_3 O_{12}$ as that of the mineral. There does not appear to be any immediate relation between danburite and topaz in chemical composition, which, considering the similarity in crystalline form, is rather remarkable. The mineral is slightly acted upon by hydrochloric acid, sufficiently to give the reaction of boracic acid with turmeric paper. When previously ignited to the point of fusion the mineral gelatinizes with acid. The crystallographic results obtained in the case of the Russell specimens do not accord with those found with the specimens from Danbury, Conn.; and this is accounted for by the crystalline specimens in the latter locality being imbedded in felspar, 'where apparent planes, at best of a problematical nature, certainly did not represent the crystalline form of the species.'

The Copper present in Coal.—An examination by Stolba of specimens of coal chiefly from Bohemia shows the invariable presence of a small quantity of copper. (*Sitzber. böhm. Gesellschaft der Wiss.*, April, 1880.) The ashes of the coals, carefully prepared, always showed a strong copper reaction; the pure coal itself contained a trace only of copper; the pyrites accompanying it gave a strong reaction. In fact the strength of the reaction appears to go hand in hand with the amount of pyrites present in the coal. The never-failing copper of the coal determines the amount of copper present in iron prepared with such coal or coke. The copper present in the coal with which we heat our ovens can be shown by the following simple method. When the coal is burnt and ceases to give a flame, and only the so-called glow is to be observed, a spoonful of pure salt is to be thrown upon it, and stirred about with a tongs or stick of wood. Immediately the azure-blue flames of carbonic oxide containing copper chloride are produced, and the appearance lasts some time. Coal which contains much pyrites exhibits the colour with great intensity and in great beauty. This, doubtless, is the cause of the colour which is so familiar to most English people, and for which many explanations have been proposed.

PHYSICS.

A Vacuum Tube of variable Resistance was exhibited before the Physical Society by Dr. Stone, at the last meeting for the season, on June 26th. It consisted of a barometer tube 32 inches long, terminating above in a short vacuum chamber arranged transversely, and closed at either end by adjustible india-rubber stoppers, through which platinum terminals passed. Above this the vertical tube continues to a glass stopcock, by means of which small quantities of air can be introduced. The foot of the tube is attached to a flexible india-rubber pipe, with a cistern similar to that of Frankland's gas apparatus. The cistern full of mercury is counterbalanced, and can be raised or lowered through the whole 32 inches. A Torricellian vacuum can thus be made in the upper chamber, or one of less perfectness. On passing the induction spark between the terminals in the former case, all the discharge is carried off, none appearing at the discharger. By gradually raising and lowering the cistern, after admitting a little air by the stopcock, the resistance of the partial vacuum can be altered within wide limits. A point can be found where the spark of breaking contact is shunted through the vacuum tube, while the weaker discharge of making contact is stopped. The induction-current is thus obtained in a single direction, a matter of some importance in physiological experiments.

Pneumatic Clocks have been successfully established in Paris, both for public and private purposes. The subscribers are supplied with dials on this system for the sum of a halfpenny per day. Air is compressed to five atmospheres in a reservoir at the central station. A distributing-clock places this in communication with distributing-pipes for twenty seconds every minute, the used air being again employed to wind automatically the original train. The distributing-tubes are of iron, 27 millim. in bore, carried underground. These, by leaden or indiarubber connexions, communicate with the affiliated dials. The dial has a small caoutchouc bellows, similar to that of the pneumatic telegraph, acting on a lever, which takes, by means of a ratchet, into a wheel of 60 teeth, carrying the minute-hand. The hour-hand is moved by the usual motion-work. Striking-clocks are also fitted up on the same system for the small increase in price of a single centime, namely, six instead of five per diem. It appears that the whole expense is from fifteen shillings to a pound per annum.

The Magneto-Optic properties of Gases are being investigated by M. Henri Becquerel. He has recently examined oxygen, hydrogen, carbonic dioxyde, nitrous oxyde, and olefiant gas. Except in the case of oxygen, the magnetic rotation of the plane of polarization due to a field of given intensity varies inversely as the square of the wave-length of the ray, as is the case in solids and liquids. This implies that violet rays are more rotated than red, or that there is a positive dispersion. In the case of oxygen, it is found that the red rays are rotated more than the green. This is the more remarkable, as oxygen gives a positive rotation as if it were a diamagnetic body. He remarks that oxygen behaves as if it were a mixture of a magnetic and a diamagnetic body, the magnetic having small negative rotation and a great negative dispersion, the diamagnetic having great rotation and small positive dispersion.

A New form of Electro Magnet was exhibited to the Physical Society by Dr. Stone. It was wound with best charcoal annealed iron wire of 5 millim. section, in four parallel circuits. Each pole was cast after winding into a solid block of paraffin, and turned in a lathe. It was expected that the latter device would increase the inductive effect of the spirals, and it appeared that the lifting power was somewhat augmented. The cores had originally been wound with large copper-wire, of the same weight, in three parallel circuits. The lifting power for moderate batteries, of from five to six Bunsen's cells, had been increased fourfold by the substitution of the iron. The object was to produce a large diffused magnetic field for the purpose of physiological experiments on anæsthesia and other nervous diseases, in which there seemed to be ground for the belief that the effects of magnetism were far from inappreciable.

The Resolving Power of Telescopes, in its experimental point of view, is examined by Lord Rayleigh. He states that the only work on the subject he is acquainted with is that of Foucault, who examined the resolving power of a telescope of 10 centim. aperture on a distant scale lighted by direct sunshine.

The object viewed in these experiments was a grating of fine wires formed by screwing the ends of a stout brass wire, bending it into a horse-shoe, and winding wire of half the pitch diameter into the grooves of the screw. The whole is fixed with solder, and the wires on one side are cut away. For rough purposes, common wire gauze of 30 to 40 meshes per inch answers. The grating was backed by a soda flame, though a common paraffin lamp may be substituted.

The telescope was provided with a cap to which various diaphragms can be fitted over the object-glass. These may be circular or rectangular, the latter being placed with its long axis parallel to the wires of the grating.

The observation consisted in finding the greatest distance at which the wires can be seen apart. This proved to be more definite than might have been expected, not differing more than 2 or 3 per cent for various observers. Two slits, half an inch long, and of ·107 and ·196 inch wide, were used. The width was taken by a wedge and measured by callipers. The distances were 91·5 and 168·5 inches. These corresponded to angular intervals between consecutive lines of $\frac{1}{4575}$ and $\frac{1}{8425}$. According to theory, the minimum angle is about that subtended by the wave-length of light, λ, at a distance equal to the width of the slit a. In this case $\lambda = 5{\cdot}89 \times 10^{-5}$ centim. and $a = {\cdot}107 \times 2{\cdot}54$ or $196 \times 2{\cdot}54$ centim. Thus: $\frac{\lambda}{a} = \frac{1}{4615}$ or $\frac{1}{8413}$, agreeing closely with the observations. Circular apertures were also used with less satisfactory results. To have equal resolving power, the circular aperture must be about a tenth part wider than the slit.

To show the dependence of resolving power on aperture, it is sufficient to look at wire-gauze backed by the sky or by a flame, through a piece of cardboard pierced by a needle and held close to the eye. By varying the distance a point is easily found at which resolution ceases; but the telescope allows the use of a wider, and therefore more easily measurable aperture.

A new Instrument for the Detection and Measurement of an Inflammable Gas in Mines was brought before the Physical Society by Mr. E. H. Liveing. He noticed that instruments already existing for this object were either physical or chemical. Of the former category were Ansell's and Forbes's: one depending on diffusion; the other on sound-velocity. Of the latter were the flame-test, Coquillion's instrument, and the one now first described.

The principle is as follows:—A mixture of marsh-gas and air, in which the former forms less than 5 per cent, is not explosive or capable of continuing its own combustion at ordinary temperatures and pressures, because the heating value of the marsh-gas is insufficient to raise the large excess of atmospheric air to the necessary ignition-temperature. If, however, such a mixture is exposed to some sufficiently heated object, especially platinum, it will burn in its immediate contact and neighbourhood, and, in so doing, add materially to the temperature of the object; the more so the larger the percentage of gas present.

Two small similar spirals of fine platinum-wire are placed in the same circuit from a small magneto-electric machine. One is enclosed in a tube containing air, the other is a cylinder of wire-gauze; both furnished with glass ends, the latter exposed to the gas to be examined. If the air contain above $\frac{1}{100}$ of marsh-gas, the spiral exposed to it increases in brilliancy, and can be made to determine the percentage of gas present. This is accomplished by placing a wedge-shaped screen between the two spirals and viewing it through a side-tube. The screen can be moved towards either end till equal illumination is obtained, and an empirical scale can then be read off, giving the percentage of gas.

Certain Effects of Stress on Soft Iron Wires have been studied by Mr. J. Ewing, at Tokio, Japan. The wire was Japanese, and annealed. It was hung vertically from a strong frame, and a tank holding 100 kilos. of water was attached to its lower end. The weight of the tank was balanced. It was circular, and of uniform diameter, the stress thus being proportionate to the height of water, as recorded horizontally on a sheet of paper drawn along by a float. A pencil traversed the paper at right angles through distances proportional to the wire's elongation. A continuous diagram was thus drawn automatically from zero to breaking point.

When a constant stress was maintained for a considerable time ($45\frac{1}{2}$ hours), the effect was remarkable. The wire, instead of continuing to lengthen at once when the flow of water was resumed, refused to stretch further until the stress rose to 40 from 35 kilos. There was in fact a new 'limit of elasticity' at this point. It broke with 41 kilos. This 'hardening effect' depended on the length of time during which the trial is interrupted, increasing more rapidly at first than after. If the load were entirely removed, no considerable lengthening took place till a far higher stress than before was reached. Thus an interval of no stress had a hardening effect, like one of constant stress. A stress, therefore, produces two effects, (1), a gradual viscous elongation, at first rapid, afterwards slow; (2), a hardening effect, also greatest at first. The effects are also perceptible in copper and brass, but much less than in soft iron.

Selenium and the Photophone forms the subject of a recent communication, from Mr. Graham Bell and Mr. Sumner Tainter, to the American Association. If the facts therein recorded bear the test of further examination, a very important and startling addition has been made to our knowledge of the possible relations between sound and light. The discovery is best given in the author's own words, as reported by our weekly contemporary, *Engineering*.

'The final result of our researches,' say the authors, 'has evidenced the class of substances sensitive to light vibrations, until we can propound the fact of such sensitiveness being a general property of all matter. We have found this property in gold, silver, platinum, iron, steel, brass, copper, zinc, lead, antimony, German silver, Jenkin's metal, Babbitt's metal, ivory, celluloid, gutta-percha, hard rubber, soft vulcanized rubber, paper, parchment, wood, mica, and silvered glass; and the only substances from which we have not obtained results are carbon and thin microscopic glass. We find that when a vibratory beam of light falls upon these substances they emit sounds—the pitch of which depends upon the frequency of the vibratory change in the light. We find further that, when we control the form or character of the light-vibration on selenium, and probably on the other substances, we control the quality of the sound and obtain all varieties of articulate speech. We can thus, without a conducting wire, as in electric telephony, speak from station to station, wherever we can project a beam of light. We have not had opportunity of testing the limit to which this photophonic influence can be extended, but we have spoken to and from points 213 metres apart; and there seems no reason to doubt that the results will be obtained at whatever distance a beam of light can be flashed from one observatory to another. The necessary privacy of our experiments hitherto has alone prevented any attempts at determining the extreme distance at which this new method of vocal communication will be available.'

They then proceed to describe the peculiar properties of selenium under the influence of light, remarking that 'all observations by previous authors had been made by means of galvanometers; but it occurred to us that the telephone, from its extreme sensitiveness to electrical influences, might be substituted with advantage. Upon consideration of the subject, however, we saw that the experiments could not be conducted in the ordinary way for the following reason: The law of audibility of the telephone is precisely analogous to the law of electric induction. No effect is produced during the passage of a continuous and steady current. It is only at the moment of change from a stronger to a weaker state, or *vice versâ*, that any audible effect is proposed, and the amount of effect is exactly proportional to the amount of variation in the current. It was, therefore, evident that the telephone could only respond to the effect produced in selenium at the moment of change from light to darkness, or *vice versâ*, and that it would be advisable to intermit the light with great rapidity, so as to produce a succession of changes in the conductivity of the selenium, corresponding in frequency to musical vibrations within the limits of the sense of hearing. For we had often noticed that currents of electricity, so feeble as to produce

scarcely any audible effects from a telephone when the circuit was simply opened or closed, caused very perceptible musical sounds when the circuit was rapidly interrupted, and that the higher the pitch of sound the more audible was the effect. We were much struck by the idea of producing sound by the action of light in this way. Upon further consideration it appeared that all the audible effects obtained from variations of electricity could also be produced by variations of light acting upon selenium. We saw that the effect could be produced at the extreme distance at which selenium would respond to the action of a luminous body, but that this distance could be indefinitely increased by the use of a parallel beam of light, so that we could telephone from one place to another without the necessity of a conducting wire between the transmitter and receiver. It was evidently necessary, in order to reduce this idea to practice, to devise an apparatus to be operated by the voice of a speaker, by which variations could be produced in a parallel beam of light, corresponding to the variations in the air produced by the voice.

'We proposed to pass light through a small number of small orifices, which might be of any convenient shape, but were preferable in the form of slits. Two similarly perforated plates were to be employed. One was to be fixed and the other attached to the centre of a diaphragm actuated by the voice, so that the vibration of the diaphragm would cause the movable plate to slide to and fro over the surface of the fixed plate, thus alternately enlarging and contracting the free orifices for the passage of light. In this way the voice of a speaker could control the amount of light passed through the perforated plates without completely obstructing its passage. This apparatus was to be placed in the path of a parallel beam of light, and the undulatory beam emerging from the apparatus could be received at some distant place upon a lens, or other apparatus, by means of which it could be condensed upon a sensitive piece of selenium placed in a local circuit with a telephone and galvanic battery. The variations in the light produced by the voice of the speaker should cause corresponding variations in the electrical resistance of the selenium employed: and the telephone in circuit with it should reproduce audibly the tones and articulations of the speaker's voice. I obtained some selenium for the purpose of producing the apparatus shown; but found that its resistance was almost infinitely greater than that of any telephone that had been constructed, and we were unable to obtain any audible effects by the action of light. We believe, however, that the obstacle could be overcome by devising mechanical arrangements for reducing the resistance of the selenium, and by constructing special telephones for the purpose. We felt so much confidence in this that, in a lecture delivered before the Royal Institute of Great Britain, upon the 17th of May, 1878, was announced the possibility of hearing a shadow by interrupting the action of light upon selenium.

'The first point to which we devoted our attention was the reduction of the resistance of crystalline selenium within manageable limits. The resistance of selenium cells employed by former experimenters was measured in millions of ohms, and we do not know of any record of a selenium cell measuring less than 250,000 ohms in the dark. We have succeeded in producing sensitive selenium cells measuring only 300 ohms in the dark, and 155

ohms in the light. All former experimenters seemed to have used platinum for the conducting part of their selenium cells, excepting Werner Siemens, who found that iron and copper might be employed. We have also discovered that brass, although chemically acted upon by selenium, forms an excellent and convenient material; indeed we are inclined to believe that the chemical action between the brass and selenium has contributed to the low resistance of our cells by forming an intimate bond of union between the selenium and the brass. We have observed that melted selenium behaves to the other substances as water to a greasy surface, and we are inclined to think that when selenium is used in connexion with metals not chemically acted upon by it, the points of contact between selenium and the metal offer a considerable amount of resistance to the passage of a galvanic current. By using brass we have been enabled to construct a large number of selenium cells of different forms. The mode of applying the selenium is as follows: The cell is heated, and, when hot enough, a stick of selenium is rubbed over the surface. In order to acquire conductivity and sensitiveness, the selenium must next undergo a process of annealing.

'We simply heat the selenium over a gas stove and observe its appearance. When the selenium attains a certain temperature, the beautiful reflecting surface becomes dimmed. A cloudiness gradually extends over it, somewhat like the film of moisture produced by breathing upon a mirror. This appearance gradually increases, and the whole surface is soon seen to be in the metallic, granular, or crystalline condition. The cell may then be taken off the stove, and cooled in any suitable way.

'We have devised about fifty forms of apparatus for varying a beam of light in the manner required, but only a few typical varieties need be shown. The source of light may be controlled, or a steady beam may be modified at any point in its path. The beam may be controlled in many ways. The best and simplest form of apparatus for producing the effect consists of a plane mirror of flexible material—such as silvered mica or microscope glass. Against the back of this mirror the speaker's voice is directed. The light reflected from this mirror is thus thrown into vibrations corresponding to those of the diaphragm itself.

'In arranging the apparatus for the purpose of reproducing sound at a distance, any powerful source of light may be used, but we have experimented chiefly with sunlight. For this purpose a large beam is concentrated by means of a lens upon the diaphragm mirror, and, after reflection, is again rendered parallel by means of another lens. The beam is received at a distant station upon a parabolic reflector, in the focus of which is placed a sensitive selenium cell, connected in a local circuit with a battery and telephone. A large number of trials of this apparatus have been made with the transmitting and receiving instruments so far apart that sounds could not be heard directly through the air. In illustration, I shall describe one of the most recent of these experiments. Mr. Tainter operated the transmitting instrument, which was placed on the top of the Franklin schoolhouse in Washington, and the sensitive receiver was arranged in one of the windows of my laboratory, 1325 L Street, at a distance of 213 metres. Upon placing the telephone to my ear I heard distinctly from the illuminated receiver the words: "Mr. Bell, if you hear what I say, come to the window and wave

your hat." We have found that articulate speech can be reproduced by the oxyhydrogen light, and even by the light of a kerosene lamp. The loudest effects obtained from light are produced by rapidly interrupting the beam by the perforated disc. The great advantage of this form of apparatus for experimental work is the noiselessness of its rotation, admitting the close approach of the receiver without interfering with the audibility of the effect heard from the latter; for it will be understood that musical tones are emitted from the receiver when no sound is made at the transmitter. A silent motion thus produces a sound. In this way musical tones have been heard even from the light of a candle. When distant effects are sought, another apparatus is used. By placing an opaque screen near the rotating disc the beam can be entirely cut off by a slight motion of the hand, and musical signals, like the dots and dashes of the Morse telegraph code, can thus be produced at the distant receiving station.'

The Action of Hollow, as compared with Solid, Steel Magnets, is considered by Herr Holtz in Wiedemann's *Annalen.* He had already come to the conclusion that solid bars do not form good permanent magnets, because the *core,* or central part, absorbs much of the magnetizing force, and because it is equivalent to an armature joining the two poles. Tubes can be forged out of sheet steel, and need not be welded at the junction. A rod and such a tube, 12½ centims. long and 13 millims. in diameter, were compared, the thickness of the tube-wall being 1¾ millims. They were magnetized to saturation, and the magnetism of the rod was found to bear the ratio to that of the tube of 1 : 1·6. When the rod and tube were 32 centims. in length and 35 millims. in diameter, the difference was as 1 : 1·5. When the tube was filled with a core of soft iron, it hardly retained enough magnetism to obey the directive action of the Earth. After six months of rest, the same magnets were again compared, with the result that in the larger pair the solid magnet retained 1, the hollow 2·5. In the smaller pair, the rod held 1, the tube 2·9. He promises to make further observations on the subject.

An Electro-dynamical paradox is described by M. Gérard-Lescuyer in the *Comptes Rendus* of July. If a current produced by a dynamo-electrical be sent into a magneto-electrical machine, the latter begins to move, but after a time it suddenly slackens, stops, and starts in the opposite direction. This reciprocating motion lasts as long as the producing current. The motive current must evidently change in direction,—a fact proved by introducing a galvanometer into the circuit. This occurs even without change in velocity of the generating machine. If it be supposed that the receiving machine receives a periodical increase of velocity, it would, by virtue of this, give rise to a current of its own, which would traverse the motor instrument in an opposite direction to that emanating from it, and reverse the polarity of the inductors. This is shown to be the case by applying a brake to the receiver sufficient to prevent its increase of velocity: the phenomenon does not then take place. With inductors of cast iron, as in the Gramme machine, the experiment is less certain, owing, as he thinks, to the residual magnetism of the cast-iron, which offers resistance to the reversal of current. Soft iron inductors, on the other hand, permit the action at the first attempt.

The Earth's Rotation was demonstrated by means of the pendulum by Leon Foucault in February 1851. He was permitted to hang a bob of 28

kilos. from a wire 67 metres long, beneath the dome of the Pantheon, in Paris. A posthumous note in explanation of the observation is published in the recently collected works of the great physicist. He fully appreciated from the first that the rapidity of the deviation is equal to the Earth's velocity multiplied into the sine of the latitude of the place of observation; corresponding simply with sidereal time at the Pole, and being infinite at the Equator. The pendulum had a period of eight seconds for each vibration. It continued in motion with a single impulse for six hours, making a complete rotation in thirty-one hours, and a deviation of 1′ 33″ in each oscillation. By this noble experiment he substantiated an important physical fact, namely, the fixedness of the plane of oscillation, as a consequence of *vis inertiæ* in matter generally. This he afterwards demonstrated still more ingeniously by means of a delicately-suspended gyroscope. Another less known form of the experiment is also recorded in his works. A thin, long, elastic rod of steel is fixed to the mandril of an ordinary lathe, being free at the farther end. If this be pulled at the free end out of its position of rest, it vibrates in a series of lines, circles, and ellipses, following each other in regular succession. The same phenomenon is seen in Wheatstone's kaleidophone. When, however, a steady oscillation has been obtained, it is not interfered with in direction by causing the mandril and the attached rod to rotate rapidly about their axis; the plane of oscillation continuing stable though the mass of the vibrating body is in motion. Even beyond this, the rotation protects the oscillatory plane against deformations due to unsymmetry of the rod, and renders it more stable than in a state of rest. Indeed, whatever form the vibratory curve may have taken up, whether linear, circular, or elliptical, this is preserved unchanged as long as the axial rotation is kept at a certain speed.

ZOOLOGY.

A Synthetic Starfish.—In the *Popular Science Review* for April (p. 192), we called attention to an interesting form of starfish, apparently bridging over the gap between the Stellerida and the Ophiurida, which had been described by Mr. W. Percy Sladen. M. E. Perrier has lately described a still more remarkable type obtained during the dredging operations of Mr. Alexander Agassiz, in the deeper parts of the Gulf of Mexico. This starfish is very delicate in its structure; it has a rounded disc distinctly separated from the arms, as in the Ophiurida, and the arms are elongated, flexible, and furnished with lateral rows of spines, thus increasing the general resemblance to the Brittle Stars. But there are twelve arms, whilst no known ophiurid has more than seven. The description of the disc is very curious, and nothing like it is known elsewhere among starfishes. It is flattened, very thin and quite destitute of any regular skeleton, the dorsal membrane being in fact literally a circular membrane stretched upon the ring formed by the basal ossicles of the arms; it is membranous and transparent, and so close to the buccal membrane that the stomach has only a space about equal to the thickness of a sheet of paper in which to lodge.

M. Perrier very justly asks what can be the usual food of an animal with such a digestive cavity. The dorsal skeleton is, however, represented by scattered perforated calcareous plates, each bearing a small spine. Through the membrane the circular canal surrounding the mouth, and the ambulacral vessels starting from it, may be recognized, but no cæcal prolongations of the stomach into the arms were to be detected. The arms possess a double row of ambulacral tubes, but no genital glands could be discerned in them. The skeleton of the arms consists of four rows of pieces, two of which form a dorsal ridge, and partially cover the others, which are placed on each side, and each of which bears a median spine enclosed in a soft sheath, clavate, and bearing at the apex a tuft of pedicellariæ, the latter being of the kind denominated 'pedicellaires croisés' by M. Perrier, and peculiarly characteristic of the Asteriadæ, the most typical group of the true Starfishes. The lateral plates form the borders of the ambulacral groove, in which the ambulacral vessel rests exactly as in the *Comatulæ*, there being no ambulacral plates, such as occur in all known Stellerida. M. Perrier remarks, that the contrast between the arms and the disc, the probable absence of genital glands from the arms, and the absence of stomachal cœca, would seem to approximate this form to the Ophiurida, just as the structure of the arms would ally it to the Comatulæ; but although in the abnormal characters above cited, and especially the want of ambulacral and buccal plates, it differs from all known Stellerida, the evidence of the pedicellariæ leads him to class it in that group, as forming an aberrant family of the Asteriadæ, in the neighbourhood of the genera *Labidiaster*, *Pedicellaster*, and *Brisinga*, which also possesses only two rows of ambulacral tubes. M. Perrier names this singular Starfish *Hymenodiscus Agassizii*. It was obtained within sight of the island of Dominica, from depths of 321 and 450 fathoms.—*Comptes Rendus*, 30th August, 1880.

Reproduction of Aphides.—M. Jules Lichtenstein has summed up the results of his observations upon the reproduction of the Aphides in a paper communicated to the French Association for the Advancement of Science. Starting from the principle that the biological cycle of an insect, commencing from the egg laid by a fertilized female, is not complete until we arrive at the same form of female fitted for fertilization, M. Lichtenstein regards all the different stages which succeed one another between these two extremes only as intermediate larval forms.

His first experiments were made on the phylloxera of the oak (*P. quercus*). The egg attached to the bark of *Quercus coccifera* gives origin at the end of April to an apterous form, which he names the *Founder*. It moults four times, and then produces egg-like bodies, which it sticks to the petiole and lower surface of the leaves. These bodies are not true eggs, and their producer is called not a female, but a *Pseudogyne*, by M. Lichtenstein. From the pseudovum proceeds the first larval form (the *Pseudogyne fondatrice*), which is apterous and larger than any of the succeeding forms. From its gemmations issues the second larval form, which, after four moults, acquires wings, but is still only a pseudogyne. It quits the *Quercus coccifera* about May 20, and settles under the leaves of *Quercus pubescens*. This is M. Lichtenstein's *Pseudogyne émigrante*.

In its new abode this second form acts like the first, depositing oviform

gemmations, which soon give birth to the third larval form, the 'Budding Pseudogyne' (*Pseud. bourgeonnante*). This is apterous, and, except in size, resembles the first larval form. This third form has the power of reproducing its like several times; that is to say, there may be several generations of the third form, but always by gemmation. It was upon this form that the experiments of Bonnet, Kyber, and other old observers were made.

Towards the autumn a fourth larval form appears, and this developes wings. This returns to the *Quercus coccifera*, which is the winter habitation of the species. M. Lichtenstein names it the 'Pupiferous Pseudogyne' (*Pseud. pupifère*), on account of the nature of its products of gemmation. The progeny of all the preceding stages was agamic; that of this fourth form consists of forms which develope into sexually perfect insects. They are of two different sizes, and the insects proceeding from them are also very different. All are apterous and quite mouthless. The smaller ones are males, the larger females, within which may be seen a large egg, filling the whole body of the insect. This is the only true female in the whole series; and after fertilization she deposits the true egg, which in the following spring will give birth to the 'founder' (*fondateur*), which formed our starting-point.

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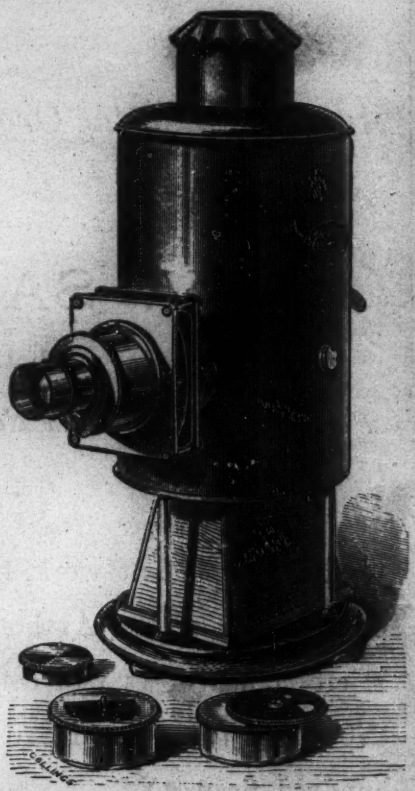

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